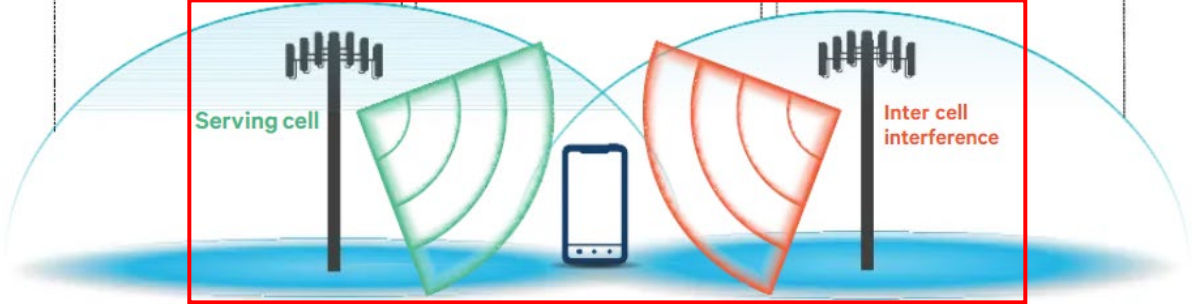


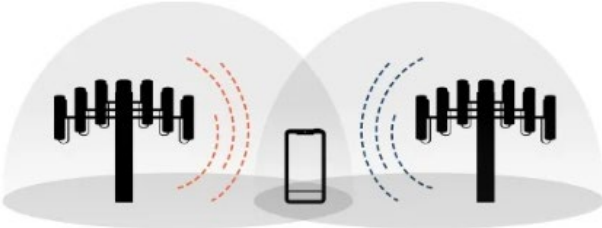
INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3

U.S. 6,947,505	Accused Products
[1.pre] In a multi-user detection system in which interfering signals are purposely allowed to exist, a parameter estimation unit for use in conjunction with a signal separation unit, in which each received signal has associated channel transfer functions, comprising:	To the extent the preamble is found to be limiting, the Accused 4G UE Instrumentalities operate in a multi-user detection system in which interfering signals are purposely allowed to exist and include a parameter estimation unit for using in conjunction with a signal separation unit, in which each received signal has associated channel transfer functions. The Accused 4G UE Instrumentalities can receive signals or streams from multiple cells, where each received signal/stream is for a user. CRS is the downlink reference signal transmitted over Almost Blank Subframes (ABSF). CRSs (i.e., the reference signal received by the UE from an eNB) are primarily used for channel transfer function estimation. They estimate the channel transfer function of the multipath propagation channel to estimate interfering symbols prior to interference cancellation, suppression. When reference symbols of different cells arrive at the same time, i.e., collide, an iterative channel estimation that reconstructs the interfering reference symbol using the available channel estimates, cancels the interfering reference symbol, and updates channel estimates, is used to improve channel transfer function. The different parameters of the received reference signal are also estimated. <u>Qualcomm LTE-Advanced Presentation:</u>

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3

U.S. 6,947,505	Accused Products
	HetNets: next generation advanced receivers To mitigate interference—even more beneficial in dense HetNets LTE advanced can cancel common signaling¹ Next step for LTE advanced: further enhanced LTE receivers²  <u>Interference Cancellation</u> ¹Performance requirement added to 3GPP for cancellation of common signaling (PSS/SSS/PBCH/CRS) in Rel 10/11. ²Broad study on UE interference suppression with & without network assistance in 3GPP R12 <u>Qualcomm LTE Advanced - Evolving and expanding into new frontiers Presentation:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products															
	Enhanced receivers offer better user experience & more capacity Interference Cancellation  <table><thead><tr><th>Interference Cancellation</th><th>Rel. 10/11</th><th>Re. 12</th></tr></thead><tbody><tr><td>Sync ref. signal</td><td>✓</td><td>✓</td></tr><tr><td>Common ref. signal</td><td>✓</td><td>✓</td></tr><tr><td>Primary broadcast channel</td><td>✓</td><td>✓</td></tr><tr><td>Data channel</td><td></td><td>✓</td></tr></tbody></table> Better user experience - Higher data rates especially at cell-edges Higher network capacity - Higher users data rate increases overall network capacity Enhanced performance for HetNets - Even more beneficial in managing interference in small cell deployments	Interference Cancellation	Rel. 10/11	Re. 12	Sync ref. signal	✓	✓	Common ref. signal	✓	✓	Primary broadcast channel	✓	✓	Data channel		✓
Interference Cancellation	Rel. 10/11	Re. 12														
Sync ref. signal	✓	✓														
Common ref. signal	✓	✓														
Primary broadcast channel	✓	✓														
Data channel		✓														
	<u>Qualcomm Interference Management Presentation:</u>															

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	Interference Management QUALCOMM • Advanced receivers – <u>Mitigate interference from broadcast signals and channels transmitted to support legacy UEs</u> – Exploit successive interference cancellation principle • Detect, decode and cancel strong interferer • Continue until desired signal can be decoded – Fully feasible for signals and channels that are broadcasted at full power • If it cannot be decoded, interference is weak and can be ignored – Not always feasible for unicast data channels • Modulation and coding is selected targeting desired user

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	Interference Management QUALCOMM • Advanced receivers – Rel 10 UEs employing advanced receivers enjoy full potential benefits of range expansion • Synchronization signals (PSS/SSS) interference cancellation – Essential for cell acquisition – known signal broadcast at full power – Need to estimate the channel before cancellation is performed • Primary broadcast channel (PBCH) interference cancellation – Essential for cell acquisition – broadcast at full power – Use decode and cancel principle – Need to estimate the channel before cancellation is performed • <u>Common reference signal (CRS) interference cancellation</u> – Known signal broadcast at full power – <u>Strong CRS interference removed</u> – <u>Essential for decoding of DL control and data channels (PDCCH/PDSCH) and accurate RRM measurements and channel feedback for range expansion UEs</u> – <u>Need to estimate the channel before cancellation is performed</u> <u>Verizon Wireless Requirements Plan:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	1.3.2.20 LTE R10 eICIC and CRS IC w/o ABS (Enhanced Inter-Cell Interference Cancellation) VZ_REQ_LTEB13NAC_36948 Applicable scenarios: • Heterogeneous network that has both small/pico cells and macro cells deployed • R10 eICIC is used to enable network to perform necessary interference management by configuring ABS subframe dynamically. • Macro homogeneous network & Heterogeneous network • CRS IC is used in macro network in non-ABS scenario • Improve PDCCH and PDSCH performance in non-colliding CRS case (user throughput) • Improve RSRP accuracy and channel estimation in colliding CRS case (improved CRS SINR and as a result better performance on PBCH and PSS/SSS) Note: UE shall not advertise any of the CRS IC and/or eICIC capability until "service enablement" direction is received from Verizon Device Marketing. (e.g., FGI115, crs-InterfHandl-r11). <u>Qualcomm Heterogeneous Network:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	For time-domain resource partitioning, a macro base-station can use almost blank subframes (ABSF) to reserve some subframes for picos. The macro base-station keeps transmitting legacy common control channels during ABSFs to enable full backward compatibility with legacy user terminals. <u>The user terminals can cancel interference on common control channels of ABSF caused either by higher power macro stations or by close-by femto stations that the user terminals are prohibited to access. The function of the advanced receiver is illustrated in Figure 6. The interference cancellation receiver fully handles colliding and non-colliding Reference Signal (RS) scenarios and removes the need for cell planning of heterogeneous deployment.</u> Almost-blank subframe from interfering base-station  Residual interference at UE: "blank" subframe [Figure 6] Advanced user equipment (UE) receiver cancels the reference signal in "almost-blank" subframes from interfering base-stations <u>TS 36.211 version 17.1.0:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	6.10 Reference signals Six types of downlink reference signals are defined: - <u>Cell-specific Reference Signal (CRS)</u> - MBSFN reference signal - UE-specific Reference Signal (DM-RS) associated with PDSCH - DeModulation Reference Signal (DM-RS) associated with EPDCCH or MPDCCH - Positioning Reference Signal (PRS) - CSI Reference Signal (CSI-RS) There is one reference signal transmitted per downlink antenna port. 6.10.1 Cell-specific Reference Signal (CRS) The UE may assume cell-specific reference signals are, unless otherwise stated in [4, clause 12], transmitted in - all downlink subframes for frame structure type 1, - all downlink subframes and DwPTS for frame structure type 2, - non-empty subframes for frame structure type 3 in a cell supporting PDSCH transmission. If special subframe configuration 10 is configured by the higher layer signalling <i>ssp10-CRS-LessDwPTS</i>, the UE cannot assume that cell specific reference signals are transmitted in the 5th OFDM symbol of the special subframe. Cell-specific reference signals are transmitted on one or several of antenna ports 0 to 3. Cell-specific reference signals are transmitted in subframes where $\Delta f = 15$ kHz only.

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3

U.S. 6,947,505	Accused Products
	6.10.1.1 Sequence generation The reference-signal sequence $r_{l,n_s}(m)$ is defined by $r_{l,n_s}(m) = \frac{1}{\sqrt{2}}(1 - 2 \cdot c(2m)) + j \frac{1}{\sqrt{2}}(1 - 2 \cdot c(2m+1)), \quad m = 0, 1, \dots, 2N_{RB}^{max,DL} - 1$ where n_s is the slot number within a radio frame and l is the OFDM symbol number within the slot. The pseudo-random sequence $c(i)$ is defined in clause 7.2. The pseudo-random sequence generator shall be initialised with $c_{init} = 2^{10} \cdot (7 \cdot (n_s' + 1) + l + 1) \cdot (2 \cdot N_{ID}^{cell} + 1) + 2 \cdot N_{ID}^{cell} + N_{CP}$ at the start of each OFDM symbol where <u>TSG-RAN WG4, Contribution # R4-126146:</u> Title: Discussion on the framework of FeICIC demodulation and CSI testing

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505 EXHIBIT 3

U.S. 6,947,505

Accused Products

3.2 CRS configuration

The other important assumption is whether colliding CRS or non-colliding CRS are configured between Pico cell and Macro cells. Assuming that there are two strong aggressor cells, the possible CRS configurations are listed in Table 1.

Table 1: Possible CRS configurations for FeICIC [8]

Case #	Descriptions	Cell ID (example)		
		S	SI	WI
Case 1	[(S,SI), (S,WI), (SI, WI)] = [C, C, C]	1	7	13
Case 2	[(S,SI), (S,WI), (SI, WI)] = [N, N, C]	1	2	8
Case 3	[(S,SI), (S,WI), (SI, WI)] = [N, N, N]	1	2	3
Case 4	[(S,SI), (S,WI), (SI, WI)] = [C, N, N]	1	7	2
Case 5	[(S,SI), (S,WI), (SI, WI)] = [N, C, N]	1	2	7

“C”: CRS collision; “N”: CRS non-collision; “S”: Serving cell;
“SI”: Stronger Interferer; “WI”: Weaker Interferer.

In [3] the first aggressor with colliding CRS and the second aggressor with non-colliding CRS were assumed. In [4] it was proposed that both colliding CRS and non-colliding CRS were configured, and CSI test for colliding CRS case shall be introduced and CSI test for non-colliding CRS case is FFS. And according to RRM discussion in the last meeting, the company also propose the assumption of the first aggressor with non-colliding CRS and the second one with colliding CRS.

The CRS configuration assumptions will impact the UE implementations and performances. The CRS colliding case fails the puncturing receiver and requires the serial CRS-cancelling to achieve the good channel estimation and other measurements for the serving cell, which needs the relatively long processing time. On the contrary, the CRS non-colliding case allows the UE to cancel the interferences parallel and makes the puncturing receiver feasible. From the implementation aspect, Case 1 is more demanding. From the performance point of view, the performance at high serving cell SNR is more sensitive to the data region interference from the aggressor cells although the interference level is relatively low.

TSG-RAN WG1, Contribution # R4-121447:

2.1. FeICIC Baseline Receiver Assumptions

We start to define the baseline receivers in more detail by describing them verbally.

- A CRS puncturing receiver is any kind of receiver that punctures REs of the wanted signal of the serving cell that are heavily interfered by CRS REs received from one or more dominant interfering cells. Knowledge of the CRS

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3

U.S. 6,947,505	Accused Products
	REs of the interfering cell(s) is assumed. Obviously, the punctured REs cannot be CRS REs of the serving cell. Hence, the CRS puncturing receiver not applicable in scenarios with colliding CRS. Transmitter side solutions, e.g. PDSCH muting corresponding to the CRS patterns of neighbor cells, are not considered as part of a CRS puncturing receiver. A CRS puncturing receiver is principally applicable to e.g. PDSCH and PDCCH with non-colliding CRS. • <u>A CRS canceling receiver is any kind of receiver that cancels CRS REs received from one or more dominant interfering cells from the wanted signal of the serving cell. Knowledge of the CRS REs of the interfering cell(s) is assumed. Canceling CRS REs from the wanted signal requires channel estimation of the channel from the UE to interfering cell.</u> The wanted signal can be any kind of channel sent by the serving cell including PDSCH, PDCCH, serving cell CRS, etc. Hence, <u>CRS canceling receivers can be applied both in scenarios with colliding and non-colliding CRS.</u> A CRS cancelling receiver is principally applicable to e.g. PDSCH and PDCCH. Figure 1 outlines the basic processing flow in the base line receiver consisting of channel estimation, CRS puncturing/canceling, MMSE based demodulation, e.g. for PDSCH, and decoding. Derivations from this processing flow are implementation specific and do not need to be defined for the base line receiver. <pre> graph LR A[Channel Estimation] --> B[CRS puncturing or canceling] B --> C[PDSCH Demodulation (MMSE)] C --> D[Decoding] subgraph RedBox [] A B C end </pre> Figure 1: Basic Receiver Diagram for PDSCH

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	According to the description for CRS canceling receivers above it needs to be distinguished between colliding and non-colliding CRS. Considering one RE only, the CRS IC system model for both cases can be written in a simplified way as: CRS IC for colliding CRS : $y_p = h_1 \cdot x_p^{(1)} + h_2 \cdot x_p^{(2)} + n \Rightarrow y_p - \hat{h}_2 \cdot x_p^{(2)}$ CRS IC for non-colliding CRS : $y_d = h_1 \cdot x_d^{(1)} + h_2 \cdot x_p^{(2)} + n \Rightarrow y_d - \hat{h}_2 \cdot x_p^{(2)}$ Here h_1 and h_2 denote the serving and interfering channel vector (matrix) and $x_p^{(i)}$ and $x_d^{(i)}$, respectively, represent pilot and data symbols, where $i = 1$ indicates the serving cell. y_p and y_d are the received REs. In both cases the interfering channel is estimated and $\hat{h}_2 \cdot x_p^{(2)}$ is subtracted from y_p and y_d. It is seen that in case of colliding CRS canceling interfering CRS mainly aims to improve channel estimation performance of the serving cell whereas in case of non-colliding CRS canceling interfering CRS aims to improve directly e.g. PDSCH and PDCCH performance. In this case channel estimation performance in the serving cell is not improved as long as no iterative receiver is applied. The RAN1 LS [1] states that both colliding and non-colliding CRS scenarios should be considered. As already mentioned, a puncturing receiver is not applicable to non-MBSFN/MBSFN ABS with colliding CRS, whereas a CRS canceling receiver can be applied both to colliding and non-colliding CRS scenarios. Hence, a CRS canceling receiver should be assumed as baseline for colliding CRS both in MBSFN and non-MBSFN ABS. <u>Qualcomm's '915 patent:</u> <i>“Certain channels, most notably Common Reference Signal (CRS) tones and/or DRS tones, have a known sequence. Thus, the channel of the cell to be cancelled can be estimated based on the CRS tones or DRS tones. For example, the UE uses the CRS and/or DRS tones transmitted from an eNB to obtain estimates of the channels between the eNB and the UE. The UE then reconstructs the CRS tones or DRS tones based on the channel estimates and the known sequence and can cells out the CRS tones or DRS tones. In this document, the CRS and/or the DRS reconstruction and cancellation procedure is referred to as “RS interference cancellation.” Control channels (PBCH, PCFICH, PHICH, PDCCH, R-PHICH (relay-PHICH), R-PDCCH (relay-PDCCH), and the like) and some data channels (PDSCH, R-PDSCH</i>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	<i>(relay PDSCH), and the like) have unknown payloads. For control channels and data channels that do not carry a Dedicated Reference Signal (DRS) tones (e.g., Demodulation Reference Signal (DMRS) tones), the UE relies on the channel estimates obtained from the CRS tones to decode, re-encode, reconstruct, and cancel out the channels. For control channels and data channels that have embedded DRS tones (e.g., Demodulation Reference Signal (DMRS) tones), the UE may rely on the channel estimates obtained from the DRS tones (e.g., Demodulation Reference Signal (DMRS) tones) to decode, re-encode, reconstruct, and cancel out the channels. Whether to use a CRS tones or a DRS tones (e.g., Demodulation Reference Signal (DMRS) tones) to obtain a channel estimate may be based at least in part on a type of the channel, transmission mode, and/or other parameters. For example, the Dedicated Reference Signal (DRS) tones may be transmitted for each channel based at least in part on a request. For example, as described above, DRS tones may be imbedded in a same resource block with the control/data channels in order to obtain a channel estimate of a corresponding channel. In this document, the control and/or data channel re-encoding, reconstruction, and cancellation procedure is referred to as “control/data channel interference cancellation’.” [Col.11, Lines 52-67 – Col.12, Lines 1-21]</i> The UE’s support of interference handling for CRS is indicated by the parameter <i>crs-InterfHandl</i> whereas <i>ss-CCH-InterfHandl</i> indicates support for synchronization signal and common channel interference handling. The eNB may send <i>CRS assistance information</i> of the aggressor cells to the UE to aid the UE to mitigate the interference from CRS of the aggressor cells.

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3

U.S. 6,947,505	Accused Products
	<i>RadioResourceConfigDedicated</i> may optionally include <i>neighCellsCRS-Info-r11</i> which is used to send <i>CRS assistance information</i> of one or several aggressor cells as shown in the figure below. <u>TS 36.331 version 17.0.0</u> <pre> CRS-AssistanceInfoList-r11 ::= SEQUENCE (SIZE (1..maxCellReport)) OF CRS-AssistanceInfo-r11 CRS-AssistanceInfo-r11 ::= SEQUENCE { physCellId-r11 PhysCellId, antennaPortsCount-r11 ENUMERATED {an1, an2, an4, spare1}, mbsfn-SubframeConfigList-r11 MBSFN-SubframeConfigList, ..., [{ mbsfn-SubframeConfigList-v1430 MBSFN-SubframeConfigList-v1430 OPTIONAL -- Need ON] } </pre> <pre> PhyLayerParameters-v1130 ::= SEQUENCE { crs-InterfHandl-r11 ENUMERATED {supported} OPTIONAL, ePDCCH-r11 ENUMERATED {supported} OPTIONAL, multiACK-C SI-Reporting-r11 ENUMERATED {supported} OPTIONAL, ss-CCH-InterfHandl-r11 ENUMERATED {supported} OPTIONAL, tdd-SpecialSubframe-r11 ENUMERATED {supported} OPTIONAL, txDiv-PUCCH1b-ChSelect-r11 ENUMERATED {supported} OPTIONAL, ul-CoMP-r11 ENUMERATED {supported} } </pre>

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3

U.S. 6,947,505	Accused Products
	<i>neighCellsCRS-Info, neighCellsCRS-InfoSCell, neighCellsCRS-InfoPSCell</i> This field contains assistance information used by the UE to mitigate interference from CRS while performing RRM/RLM/CSI measurement or data demodulation or DL control channel demodulation. When the received CRS assistance information is for a cell with CRS non-colliding with that of the CRS of the cell to measure, the UE may use the CRS assistance information to mitigate CRS interference. When the received CRS assistance information is for a cell with CRS colliding with that of the CRS of the cell to measure, the UE may use the CRS assistance information to mitigate CRS interference RRM/RLM (as specified in TS 36.133 [16]) and for CSI (as specified in TS 36.101 [42]) on the subframes indicated by <i>measSubframePatternPCell, measSubframePatternConfigNeigh, csi-MeasSubframeSet1</i> if configured, and the CSI subframe set 1 if <i>csi-MeasSubframeSets-r12</i> is configured. The UE may use CRS assistance information to mitigate CRS interference from the cells in the <i>CRS-AssistanceInfoList</i> for the demodulation purpose or DL control channel demodulation as specified in TS 36.101 [42]. EUTRAN does not configure <i>neighCellsCRS-Info-r11</i> or <i>neighCellsCRS-Info-r13</i> if <i>eimta-MainConfigPCell-r12</i> is configured.
[1.a] a signal processor for determining said channel transfer functions for each received signal; and	The Accused 4G UE Instrumentalities include a signal processor for determining said channel transfer functions for each received signal. The Accused 4G UE Instrumentalities need estimates of the channel (“channel transfer function”) between the eNB and the UE to estimate symbols of the multiple users/data streams for interference cancellation/suppression or for data demodulation. Channel estimation is a signal processing task and is to be carried out by a signal processor in the UE. At acquisition time, when a UE selects and acquires the signal transmitted by a base station, the UE needs to acquire and estimate, e.g., system timing, frequency, Doppler and effects of multipaths in the channel. For instance, in an OFDM system, the effects of multipath, phases and gains superimposed on the different resource elements (frequency tones), are estimated using reference symbols transmitted by the base stations. Parameters corresponding to timing, frequency offset, Doppler and effects of multipaths are estimated in acquisition state and tracked when on the traffic channel in a connected state. Acquisition and estimation of these parameters is a signal processing function carried out by a signal processing module ("parameter estimation unit"). When the UE transitions from the acquisition state to the connected state a UE channel parameter

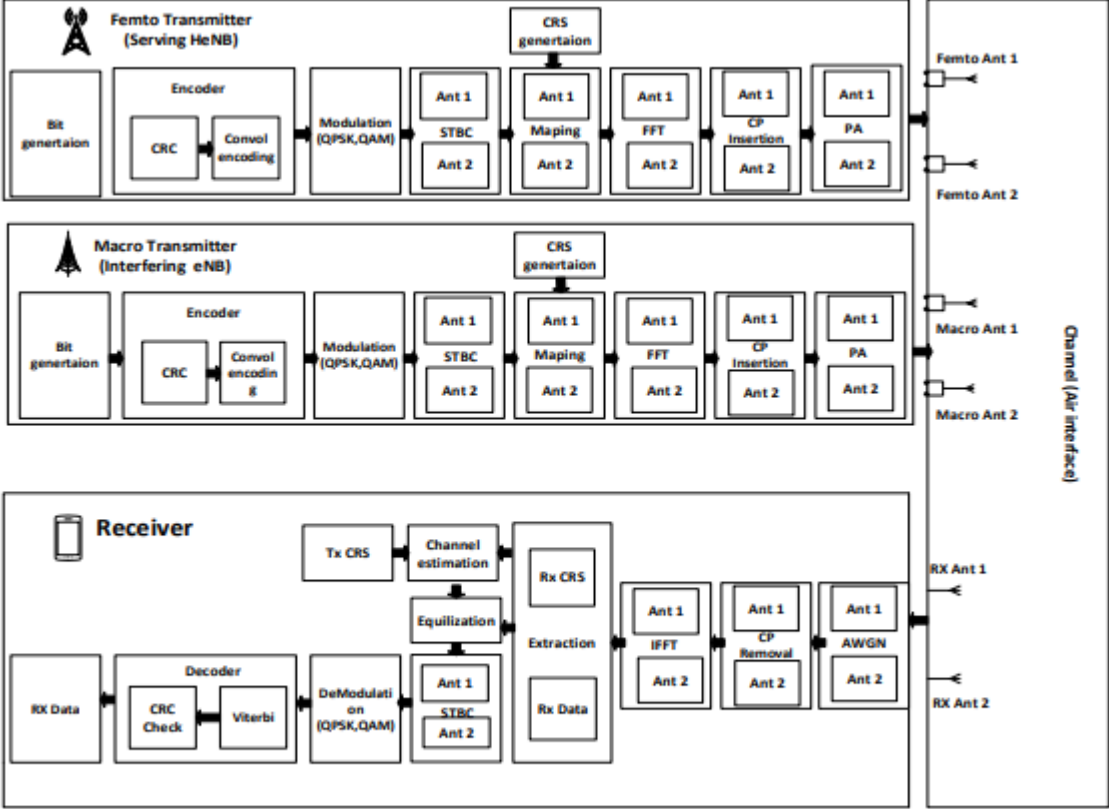
**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	tracking module ("tracking unit") uses the channel parameters from the acquisition state and tracks these parameters to maintain the call when on the traffic channel. <u>TSG-RAN WG1, Contribution # R4-121447:</u> 2.1. FeICIC Baseline Receiver Assumptions We start to define the baseline receivers in more detail by describing them verbally. • A CRS puncturing receiver is any kind of receiver that punctures REs of the wanted signal of the serving cell that are heavily interfered by CRS REs received from one or more dominant interfering cells. Knowledge of the CRS REs of the interfering cell(s) is assumed. Obviously, the punctured REs cannot be CRS REs of the serving cell. Hence, the CRS puncturing receiver not applicable in scenarios with colliding CRS. Transmitter side solutions, e.g. PDSCH muting corresponding to the CRS patterns of neighbor cells, are not considered as part of a CRS puncturing receiver. A CRS puncturing receiver is principally applicable to e.g. PDSCH and PDCCH with non-colliding CRS. • A CRS canceling receiver is any kind of receiver that cancels CRS REs received from one or more dominant interfering cells from the wanted signal of the serving cell. Knowledge of the CRS REs of the interfering cell(s) is assumed. Canceling CRS REs from the wanted signal requires channel estimation of the channel from the UE to interfering cell. The wanted signal can be any kind of channel sent by the serving cell including PDSCH, PDCCH, serving cell CRS, etc. Hence, CRS canceling receivers can be applied both in scenarios with colliding and non-colliding CRS. A CRS cancelling receiver is principally applicable to e.g. PDSCH and PDCCH. Figure 1 outlines the basic processing flow in the base line receiver consisting of channel estimation, CRS puncturing/canceling, MMSE based demodulation, e.g. for PDSCH, and decoding. Derivations from this processing flow are implementation specific and do not need to be defined for the base line receiver. <pre> graph LR A[Channel Estimation] --> B[CRS puncturing or canceling] B --> C[PDSCH Demodulation (MMSE)] C --> D[Decoding] </pre> Figure 1: Basic Receiver Diagram for PDSCH

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	According to the description for CRS canceling receivers above it needs to be distinguished between colliding and non-colliding CRS. Considering one RE only, the CRS IC system model for both cases can be written in a simplified way as: $\text{CRS IC for colliding CRS : } \mathbf{y}_p = \mathbf{h}_1 \cdot \mathbf{x}_p^{(1)} + \mathbf{h}_2 \cdot \mathbf{x}_p^{(2)} + \mathbf{n} \Rightarrow \mathbf{y}_p - \hat{\mathbf{h}}_2 \cdot \mathbf{x}_p^{(2)}$ $\text{CRS IC for non-colliding CRS : } \mathbf{y}_d = \mathbf{h}_1 \cdot \mathbf{x}_d^{(1)} + \mathbf{h}_2 \cdot \mathbf{x}_p^{(2)} + \mathbf{n} \Rightarrow \mathbf{y}_d - \hat{\mathbf{h}}_2 \cdot \mathbf{x}_p^{(2)}$ Here $\mathbf{h}_1$ and $\mathbf{h}_2$ denote the serving and interfering channel vector (matrix) and $\mathbf{x}_p^{(i)}$ and $\mathbf{x}_d^{(i)}$, respectively, represent pilot and data symbols, where $i = 1$ indicates the serving cell. $\mathbf{y}_p$ and $\mathbf{y}_d$ are the received REs. In both cases the interfering channel is estimated and $\hat{\mathbf{h}}_2 \cdot \mathbf{x}_p^{(2)}$ is subtracted from $\mathbf{y}_p$ and $\mathbf{y}_d$. It is seen that in case of colliding CRS canceling interfering CRS mainly aims to improve channel estimation performance of the serving cell whereas in case of non-colliding CRS canceling interfering CRS aims to improve directly e.g. PDSCH and PDCCH performance. In this case channel estimation performance in the serving cell is not improved as long as no iterative receiver is applied. The RAN1 LS [1] states that both colliding and non-colliding CRS scenarios should be considered. As already mentioned, a puncturing receiver is not applicable to non-MBSFN/MBSFN ABS with colliding CRS, whereas a CRS canceling receiver can be applied both to colliding and non-colliding CRS scenarios. Hence, a CRS canceling receiver should be assumed as baseline for colliding CRS both in MBSFN and non-MBSFN ABS. <u>Understanding ICI in LTE HetNet, Thesis:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	 The diagram illustrates a system model for a femto network. It consists of three main components: a Femto Transmitter (Serving HeNB), a Macro Transmitter (Interfering eNB), and a Receiver. Femto Transmitter (Serving HeNB): This block includes a Bit generation section, an Encoder (containing CRC and Convolutional encoding), and a Modulation (QPSK, QAM) section. The output of the modulation is fed into a STBC block, which is then connected to a Mapping block. The Mapping block is connected to a CRS generation block and a PA (Power Amplifier) block. The PA block is connected to two antennas, Ant 1 and Ant 2. The output of the PA block is connected to a Channel (Air interface) block. Macro Transmitter (Interfering eNB): This block has a similar architecture to the Femto Transmitter, including Bit generation, Encoder, Modulation, STBC, Mapping, CRS generation, and PA blocks, connected to two antennas, Ant 1 and Ant 2. The output of the PA block is also connected to the Channel (Air interface) block. Receiver: This block includes a Tx CRS block, a Channel estimation block, an Rx CRS block, an Equilization block, an Extraction block, a DeModulation (QPSK, QAM) block, a Decoder (containing CRC Check and Viterbi), and an RX Data block. The input to the Receiver is from the Channel (Air interface) block, which is connected to two antennas, RX Ant 1 and RX Ant 2. The output of the RX Ant 1 and RX Ant 2 is connected to the Rx CRS block. The Rx CRS block is connected to the Equilization block, which is connected to the Extraction block. The Extraction block is connected to the DeModulation block, which is connected to the Decoder. The Decoder is connected to the RX Data block. Figure 6.1: System model 3GPP TR 36.866 V12.0.1:

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3

U.S. 6,947,505	Accused Products
	9.1.5.2 Alternative 2 Generally, the system level modelling methodology for SLIC is carried out by two steps. The first step is to derive the post-processing SINR per subcarrier. After that, the simulator predicts the instantaneous BLER for each transmission block by a link quality model (such as MIESM, EESM etc.) based on the input SINRs. Here, we will only focus on how to obtaining of post-processing SINRs. For simplicity, we assume the target UE eliminates the strongest interference, and only one layer is transmitted for both target UE and interfering UE. The received downlink signal for each subcarrier can be written as $y = H_s x_s + H_1 x_1 + \sum_{k=2}^{N-1} H_k x_k + n \quad (9.47)$ Where H_1 denotes the effective channel from the strongest interfering cell to the target UE and x_1 denotes the strongest interfering symbol. In the first place, the strongest interference signal is detected with its corresponding post-processed SINR, take MMSE receiver as an example, $\gamma_{MMSE-1st-inf} = w_{MMSE-1st-inf} \cdot \tilde{H}_1 / (1 - w_{MMSE-1st-inf} \cdot \tilde{H}_1) \quad (9.48)$ where $w_{MMSE-1st-inf} = \tilde{H}_1^H \left(\tilde{H}_1 \tilde{H}_1^H + \text{diag} \left(\tilde{H}_s \tilde{H}_s^H + \sum_{k=2}^{N-1} \tilde{H}_k \tilde{H}_k^H + \sigma_N^2 \cdot I \right) \right)^{-1} \quad (9.49)$

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	Where H_I denotes the effective channel from the strongest interfering cell to the target UE and x_1 denotes the strongest interfering symbol. In the first place, the strongest interference signal is detected with its corresponding post-processed SINR, take MMSE receiver as an example, $\gamma_{MMSE-lst-inf} = w_{MMSE-lst-inf} \cdot \tilde{H}_1 / (1 - w_{MMSE-lst-inf} \cdot \tilde{H}_1) \quad (9.48)$ where $w_{MMSE-lst-inf} = \tilde{H}_1^H \left(\tilde{H}_1 \tilde{H}_1^H + \text{diag} \left(\tilde{H}_s \tilde{H}_s^H + \sum_{k=2}^{N-1} \tilde{H}_k \tilde{H}_k^H + \sigma_N^2 \cdot I \right) \right)^{-1} \quad (9.49)$ Once the strongest interference signal is detected, it could be removed from the received signal. However, the strongest interference signal cannot be completely removed in practical system. Let e_k denotes the residual error and $\bar{\sigma}$ be the variance of demodulated symbols residual error, $e = \tilde{H}_1 x_1 - \tilde{H}_1 \tilde{x}_1 = \tilde{H}_1 (x_1 - \tilde{x}_1), \quad \bar{\sigma} = \frac{1}{L} \sum_{l=1}^L \ x_{1l} - \tilde{x}_{1l}\ ^2, \quad (9.50)$ where L is the number of trials. <u>Qualcomm's '915 patent:</u> <i>“Certain channels, most notably Common Reference Signal (CRS) tones and/or DRS tones, have a known sequence. Thus, the channel of the cell to be cancelled can be estimated based on the CRS tones or DRS tones. For example, the UE uses the CRS and/or DRS tones transmitted from an eNB to obtain estimates of the channels between the eNB and the UE. The UE then reconstructs the CRS tones or DRS tones based on the channel estimates and the known sequence, and can cells out the CRS tones or DRS tones. In this document, the CRS and/or the DRS reconstruction and cancellation procedure is referred</i>

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3

U.S. 6,947,505	Accused Products
	<i>to as “RS interference cancellation.” Control channels (PBCH, PCFICH, PHICH, PDCCH, R-PHICH (relay-PHICH), R-PDCCH (relay-PDCCH), and the like) and some data channels (PDSCH, R-PDSCH (relay PDSCH), and the like) have unknown payloads. For control channels and data channels that do not carry a Dedicated Reference Signal (DRS) tones (e.g., Demodulation Reference Signal (DMRS) tones), the UE relies on the channel estimates obtained from the CRS tones to decode, re-encode, reconstruct, and cancel out the channels. For control channels and data channels that have embedded DRS tones (e.g., Demodulation Reference Signal (DMRS) tones), the UE may rely on the channel estimates obtained from the DRS tones (e.g., Demodulation Reference Signal (DMRS) tones) to decode, re-encode, reconstruct, and cancel out the channels. Whether to use a CRS tones or a DRS tones (e.g., Demodulation Reference Signal (DMRS) tones) to obtain a channel estimate may be based at least in part on a type of the channel, transmission mode, and/or other parameters. For example, the Dedicated Reference Signal (DRS) tones may be trans mitted for each channel based at least in part on a request. For example, as described above, DRS tones may be imbedded in a same resource block with the control/data channels in order to obtain a channel estimate of a corresponding channel. In this document, the control and/or data channel re-encoding, reconstruction, and cancellation procedure is referred to as “control/data channel interference cancellation'.” [Col.11, Lines 52-67 – Col.12, Lines 1-21]</i> <i>“The approach of FIGS. 8-10 also works for a colliding CRS scenario and/or a colliding DRS Scenario, but the approach of FIGS. 6 and 7 may be selected for colliding CRS scenarios and/or colliding DRS scenarios for one or more reasons. It is generally the case that the approach of FIGS. 8-10 has a higher</i>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	<i>complexity than the approach of FIGS. 6 and 7. Furthermore, if an iterative interference cancellation approach is employed in a colliding CRS scenario and/or a colliding DRS scenario, it may be advantageous to use the approach of FIGS. 6 and 7 to reduce the number of iterations in control/data channel interference cancellation. Specifically, in an iterative approach of FIGS. 6 and 7, the control/data channel decoding on the serving and neighbor cells are performed with the final channel estimates that are obtained after all the CRS and/or DRS interference cancellation iterations are completed, whereas in an iterative approach according to FIGS. 8-10, the control/data channel decoding of the serving and neighbor cells are performed with intermediate channel estimates that are available on the given iteration. Because the intermediate channel estimates are less accurate than the final channel estimates, it is desirable to implement more iterations for the approach according to FIGS. 8-10 than for the approach according to FIGS. 6-7.” .” [Col.15, Lines 59-67 – Col.16, Lines 1-14]</i> If this element is not literally satisfied by the disclosures cited herein, it is satisfied under the doctrine of equivalents, by the disclosures cited herein because the accused functionality would be insubstantially different from or function in the same way to provide the same result as the relevant claim element.
[1.b] means coupled to said channel transfer function determining signal processor for providing	The Accused 4G UE Instrumentalities include means coupled to said channel transfer function determining signal processor for providing uninterrupted estimates of the channel transfer function parameters on a real-time basis by first deriving the estimated channel transfer function for each of said interfering signals.

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3

U.S. 6,947,505	Accused Products
uninterrupted estimates of the channel transfer function parameters on a real-time basis by first deriving the estimated channel transfer function for each of said interfering signals.	This term is governed by 35 U.S.C. sec. 112 para. 6. The claimed function is providing uninterrupted estimates of the channel transfer function parameters on a real-time basis by first deriving the estimated channel transfer function for each of said interfering signals. The Accused 4G UE Instrumentalities make initial channel transfer function estimates during setting up a data connection. In the case of colliding (interfering) reference symbols received at the UE from streams of different cells, such as CRS or DMRS symbols, means coupled to the UE channel transfer function determining signal processor are used to provide uninterrupted estimates of the channel transfer function parameters on a real-time basis. This can enhance channel transfer function estimates of each user. For example, the means utilizes the initial estimates of the channel transfer function for each user to carry out an iteration to reconstruct the reference symbols of the users that cause interference to the reference symbols of a user by using the existing channel estimates to cancel the estimated interfering reference symbols from the received signal. This iteration updates the channel transfer function estimates of each user. Thus, the Accused 4G UE Instrumentalities provide uninterrupted estimates of the channel transfer function parameters on a real-time basis. The corresponding structure is a parameter tracking unit and equivalents thereof. See, e.g., fig. 1, Col.5, Lines 20-40, Col. 6, Lines 9-23, fig. 3, fig. 4 (item 90, 90', 90'), Col 7, Lines 45-Col 8, Line 40. As described above, The Accused 4G UE Instrumentalities need estimates of the channel ("channel transfer function") between the eNB and the UE to estimate symbols of the multiple users/data streams for interference cancellation/suppression or for data demodulation. Channel estimation is a signal processing task and is to be carried out by a signal processor in the UE. At acquisition time, when a UE

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3

U.S. 6,947,505	Accused Products
	selects and acquires the signal transmitted by a base station, the UE needs to acquire and estimate, e.g., system timing, frequency, Doppler and effects of multipaths in the channel. For instance, in an OFDM system, the effects of multipath, phases and gains superimposed on the different resource elements (frequency tones), are estimated using reference symbols transmitted by the base stations. Parameters corresponding to timing, frequency offset, Doppler and effects of multipaths are estimated in acquisition state and tracked when on the traffic channel in a connected state. Acquisition and estimation of these parameters is a signal processing function carried out by a signal processing module ("parameter estimation unit"). When the UE transitions from the acquisition state to the connected state a UE channel parameter tracking module ("tracking unit") uses the channel parameters from the acquisition state and tracks these parameters to maintain the call when on the traffic channel. <u>TS 36.211 version 17.1.0:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	6.10 Reference signals Six types of downlink reference signals are defined: - <u>Cell-specific Reference Signal (CRS)</u> - MBSFN reference signal - UE-specific Reference Signal (DM-RS) associated with PDSCH - DeModulation Reference Signal (DM-RS) associated with EPDCCH or MPDCCH - Positioning Reference Signal (PRS) - CSI Reference Signal (CSI-RS) There is one reference signal transmitted per downlink antenna port. 6.10.1 Cell-specific Reference Signal (CRS) The UE may assume cell-specific reference signals are, unless otherwise stated in [4, clause 12], transmitted in - all downlink subframes for frame structure type 1, - all downlink subframes and DwPTS for frame structure type 2, - non-empty subframes for frame structure type 3 in a cell supporting PDSCH transmission. If special subframe configuration 10 is configured by the higher layer signalling <i>ssp10-CRS-LessDwPTS</i>, the UE cannot assume that cell specific reference signals are transmitted in the 5th OFDM symbol of the special subframe. Cell-specific reference signals are transmitted on one or several of antenna ports 0 to 3. Cell-specific reference signals are transmitted in subframes where $\Delta f = 15$ kHz only.

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3

U.S. 6,947,505	Accused Products
	6.10.1.1 Sequence generation The reference-signal sequence $r_{l,n_s}(m)$ is defined by $r_{l,n_s}(m) = \frac{1}{\sqrt{2}}(1 - 2 \cdot c(2m)) + j \frac{1}{\sqrt{2}}(1 - 2 \cdot c(2m+1)), \quad m = 0, 1, \dots, 2N_{RB}^{\max, DL} - 1$ where n_s is the slot number within a radio frame and l is the OFDM symbol number within the slot. The pseudo-random sequence $c(i)$ is defined in clause 7.2. The pseudo-random sequence generator shall be initialised with $c_{init} = 2^{10} \cdot (7 \cdot (n_s' + 1) + l + 1) \cdot (2 \cdot N_{ID}^{cell} + 1) + 2 \cdot N_{ID}^{cell} + N_{CP}$ at the start of each OFDM symbol where <u>TSG-RAN WG1, Contribution # R4-121447:</u> 2.1. FeICIC Baseline Receiver Assumptions We start to define the baseline receivers in more detail by describing them verbally. • A CRS puncturing receiver is any kind of receiver that punctures REs of the wanted signal of the serving cell that are heavily interfered by CRS REs received from one or more dominant interfering cells. Knowledge of the CRS

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	REs of the interfering cell(s) is assumed. Obviously, the punctured REs cannot be CRS REs of the serving cell. Hence, the CRS puncturing receiver not applicable in scenarios with colliding CRS. Transmitter side solutions, e.g. PDSCH muting corresponding to the CRS patterns of neighbor cells, are not considered as part of a CRS puncturing receiver. A CRS puncturing receiver is principally applicable to e.g. PDSCH and PDCCH with non-colliding CRS. • A CRS canceling receiver is any kind of receiver that cancels CRS REs received from one or more dominant interfering cells from the wanted signal of the serving cell. Knowledge of the CRS REs of the interfering cell(s) is assumed. Canceling CRS REs from the wanted signal requires channel estimation of the channel from the UE to interfering cell. The wanted signal can be any kind of channel sent by the serving cell including PDSCH, PDCCH, serving cell CRS, etc. Hence, CRS canceling receivers can be applied both in scenarios with colliding and non-colliding CRS. A CRS cancelling receiver is principally applicable to e.g. PDSCH and PDCCH. Figure 1 outlines the basic processing flow in the base line receiver consisting of channel estimation, CRS puncturing/canceling, MMSE based demodulation, e.g. for PDSCH, and decoding. Derivations from this processing flow are implementation specific and do not need to be defined for the base line receiver. <pre> graph LR A[Channel Estimation] --> B[CRS puncturing or canceling] B --> C[PDSCH Demodulation (MMSE)] C --> D[Decoding] </pre> Figure 1: Basic Receiver Diagram for PDSCH

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	According to the description for CRS canceling receivers above it needs to be distinguished between colliding and non-colliding CRS. Considering one RE only, the CRS IC system model for both cases can be written in a simplified way as: $\text{CRS IC for colliding CRS : } \mathbf{y}_p = \mathbf{h}_1 \cdot \mathbf{x}_p^{(1)} + \mathbf{h}_2 \cdot \mathbf{x}_p^{(2)} + \mathbf{n} \Rightarrow \mathbf{y}_p - \hat{\mathbf{h}}_2 \cdot \mathbf{x}_p^{(2)}$ $\text{CRS IC for non-colliding CRS : } \mathbf{y}_d = \mathbf{h}_1 \cdot \mathbf{x}_d^{(1)} + \mathbf{h}_2 \cdot \mathbf{x}_p^{(2)} + \mathbf{n} \Rightarrow \mathbf{y}_d - \hat{\mathbf{h}}_2 \cdot \mathbf{x}_p^{(2)}$ Here $\mathbf{h}_1$ and $\mathbf{h}_2$ denote the serving and interfering channel vector (matrix) and $\mathbf{x}_p^{(i)}$ and $\mathbf{x}_d^{(i)}$, respectively, represent pilot and data symbols, where $i = 1$ indicates the serving cell. $\mathbf{y}_p$ and $\mathbf{y}_d$ are the received REs. In both cases the interfering channel is estimated and $\hat{\mathbf{h}}_2 \cdot \mathbf{x}_p^{(2)}$ is subtracted from $\mathbf{y}_p$ and $\mathbf{y}_d$. It is seen that in case of colliding CRS canceling interfering CRS mainly aims to improve channel estimation performance of the serving cell whereas in case of non-colliding CRS canceling interfering CRS aims to improve directly e.g. PDSCH and PDCCH performance. In this case channel estimation performance in the serving cell is not improved as long as no iterative receiver is applied. The RAN1 LS [1] states that both colliding and non-colliding CRS scenarios should be considered. As already mentioned, a puncturing receiver is not applicable to non-MBSFN/MBSFN ABS with colliding CRS, whereas a CRS canceling receiver can be applied both to colliding and non-colliding CRS scenarios. Hence, a CRS canceling receiver should be assumed as baseline for colliding CRS both in MBSFN and non-MBSFN ABS. <u>Qualcomm's '915 patent:</u> <i>“FIG. 6A is a block diagram conceptually illustrating a colliding CRS scenario before interference cancellation is performed, according to one aspect of the present disclosure. In FIG. 6A, the horizontal axes represent frequency. Reference signal (e.g., CRS) tones and control/data tones are shown for a Sub carrier of a neighbor cell and a serving cell. As shown in FIG. 6A, serving cell CRS tones see interference from the CRS tones of the neighbor cell. To improve interference cancellation results, according to one aspect the UE decouples CRS interference cancellation and control/data channel interference cancellation in a colliding CRS tone scenario. That is, the UE first performs CRS interference cancellation to estimate the serving cell channels and then proceeds with neighbor cell and</i>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	<i>serving cell control/data channel interference cancellation and decoding.” [Col.12, Lines 63 – Col.13, Lines 10]</i> <i>“In one example, the UE performs the decoupled interference cancellation/channel estimation process as described above based on CRS tones and/or DRS tones according to the following order (e.g., when the neighboring cell is stronger):</i> <i>1. Neighbor cell channel estimation:</i> <i>2. Neighbor cell CRS interference cancellation and/or neighbor cell DRS interference cancellation;</i> <i>3. Serving cell channel estimation;</i> <i>4. For iterative interference cancellation (e.g., when the cells are of similar strength), perform serving cell CRS interference cancellation and/or perform serving cell DRS interference cancellation and repeat 1-4 a number of times in a well-known manner.</i> <i>5. Neighbor cell control/data channel decoding:</i> <i>6. Neighbor cell control/data channel interference cancellation;</i> <i>7. Serving cell control/data channel decoding:</i>

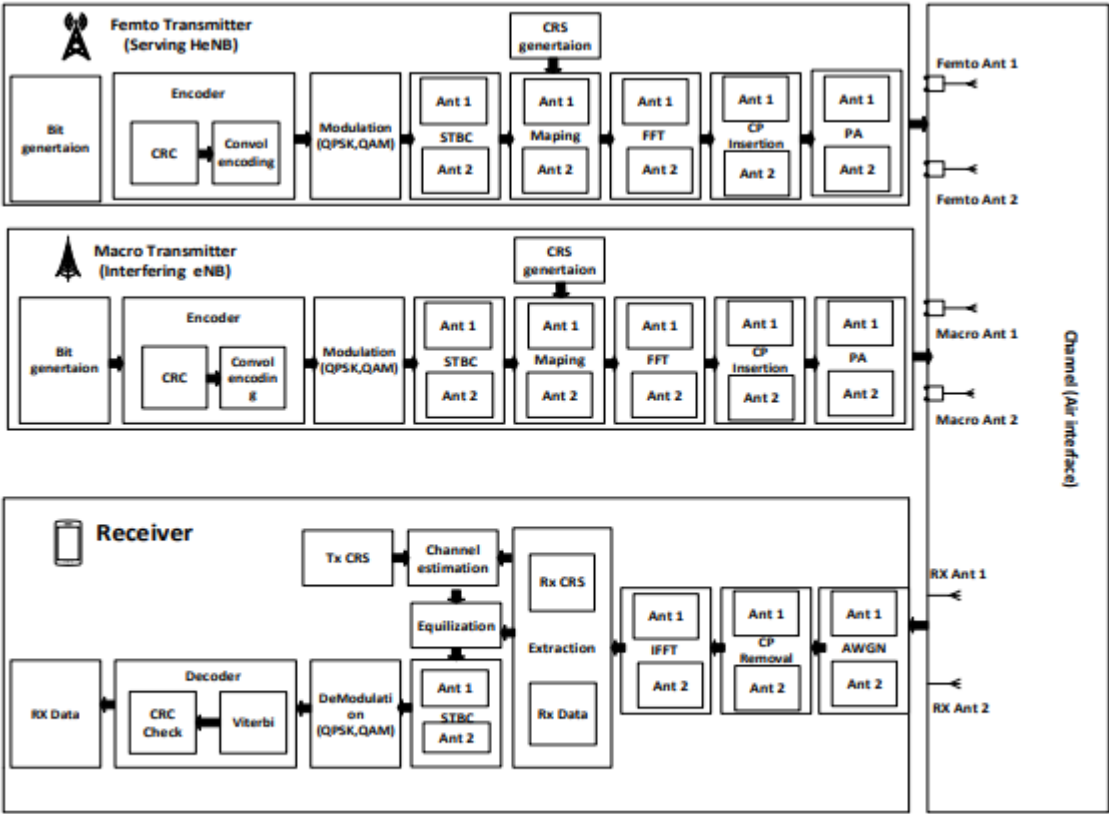
**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	<i>8. For iterative interference cancellation (e.g., when the cells are of similar strength), perform serving cell control/data channel interference cancellation and repeat 5-8 a number of times in a well-known manner. .” [Col.13, Lines 58 – Col.14, Lines 11]</i> <i>“The approach of FIGS. 8-10 also works for a colliding CRS scenario and/or a colliding DRS Scenario, but the approach of FIGS. 6 and 7 may be selected for colliding CRS scenarios and/or colliding DRS scenarios for one or more reasons. It is generally the case that the approach of FIGS. 8-10 has a higher complexity than the approach of FIGS. 6 and 7. Furthermore, if an iterative interference cancellation approach is employed in a colliding CRS scenario and/or a colliding DRS scenario, it may be advantageous to use the approach of FIGS. 6 and 7 to reduce the number of iterations in control/data channel interference cancellation. Specifically, in an iterative approach of FIGS. 6 and 7, the control/data channel decoding on the serving and neighbor cells are performed with the final channel estimates that are obtained after all the CRS and/or DRS interference cancellation iterations are completed, whereas in an iterative approach according to FIGS. 8-10, the control/data channel decoding of the serving and neighbor cells are performed with intermediate channel estimates that are available on the given iteration. Because the intermediate channel estimates are less accurate than the final channel estimates, it is desirable to implement more iterations for the approach according to FIGS. 8-10 than for the approach according to FIGS. 6-7.” [Col.15, Lines 59-67 – Col.16, Lines 1-14]</i> <u>CRS in LTE</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505	Accused Products
	1. Purpose of Cell-specific Reference Signal (CRS): a. Synchronization: • One of the primary purposes of CRS is to facilitate synchronization between the User Equipment (UE) and the cell (eNodeB or base station). It provides a known signal that helps the UE synchronize its reception timing with the transmission timing of the cell. b. Channel Estimation: • CRS aids in channel estimation at the receiver. By analyzing the received CRS, the UE can estimate the characteristics of the wireless channel, such as the channel gain and phase, which is essential for reliable communication. <u>Understanding ICI in LTE HetNet, Thesis:</u>

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3

U.S. 6,947,505	Accused Products
	 Figure 6.1: System model If this element is not literally satisfied by the disclosures cited herein, it is satisfied under the doctrine of equivalents, by the disclosures cited herein because the accused functionality would be insubstantially different from or function in the same way to provide the same result as the relevant claim element.

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3

'505 Claim 3	<u>Accused Products (UE)</u>
[3] The parameter estimation unit of claim 1, wherein the multi-user detection system includes providing an acquisition channel, and wherein the first derived estimated channel transfer function is derived from acquisition channel parameters.	The Accused 4G UE Instrumentalities include a parameter estimation unit, wherein the multi-user detection system includes providing an acquisition channel, and wherein the first derived estimated channel transfer function is derived from acquisition channel parameters. LTE uses Synchronization Signal Block (SSB) (“acquisition channel”) to detect the signal transmitted by an eNB, acquire timing, and estimate frequency offset, Doppler, and initial channel parameters to decode the PBCH channel. These parameters are carried over to the next call state of idle or connected mode. The synchronization signal identifies the physical-layer cell ID that is further used by the CRS to estimate the channel transfer function. <u>TS 36.211 version 17.1.0:</u> <u>6.11 Synchronization signals</u> There are 504 unique physical-layer cell identities. The physical-layer cell identities are grouped into 168 unique physical-layer cell-identity groups, each group containing three unique identities. The grouping is such that each physical-layer cell identity is part of one and only one physical-layer cell-identity group. <u>A physical-layer cell identity $N_{ID}^{cell} = 3 N_{ID}^{(1)} + N_{ID}^{(2)}$ is thus uniquely defined by a number $N_{ID}^{(1)}$ in the range of 0 to 167, representing the physical-layer cell-identity group, and a number $N_{ID}^{(2)}$ in the range of 0 to 2, representing the physical-layer identity within the physical-layer cell-identity group.</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 3	<u>Accused Products (UE)</u>
	6.10 Reference signals Six types of downlink reference signals are defined: - Cell-specific Reference Signal (CRS) - MBSFN reference signal - UE-specific Reference Signal (DM-RS) associated with PDSCH - DeModulation Reference Signal (DM-RS) associated with EPDCCH or MPDCCH - Positioning Reference Signal (PRS) - CSI Reference Signal (CSI-RS) There is one reference signal transmitted per downlink antenna port. 6.10.1 Cell-specific Reference Signal (CRS) The UE may assume cell-specific reference signals are, unless otherwise stated in [4, clause 12], transmitted in - all downlink subframes for frame structure type 1, - all downlink subframes and DwPTS for frame structure type 2, - non-empty subframes for frame structure type 3 in a cell supporting PDSCH transmission. If special subframe configuration 10 is configured by the higher layer signalling <i>ssp10-CRS-LessDwPTS</i>, the UE cannot assume that cell specific reference signals are transmitted in the 5th OFDM symbol of the special subframe. Cell-specific reference signals are transmitted on one or several of antenna ports 0 to 3. Cell-specific reference signals are transmitted in subframes where $\Delta f = 15$ kHz only.

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 3	<u>Accused Products (UE)</u>
	6.10.1.1 Sequence generation The reference-signal sequence $r_{l,n_s}(m)$ is defined by $r_{l,n_s}(m) = \frac{1}{\sqrt{2}}(1 - 2 \cdot c(2m)) + j \frac{1}{\sqrt{2}}(1 - 2 \cdot c(2m+1)), \quad m = 0, 1, \dots, 2N_{RB}^{max,DL} - 1$ where n_s is the slot number within a radio frame and l is the OFDM symbol number within the slot. The pseudo-random sequence $c(i)$ is defined in clause 7.2. The pseudo-random sequence generator shall be initialised with $c_{init} = 2^{10} \cdot (7 \cdot (n'_s + 1) + l + 1) \cdot (2 \cdot N_{ID}^{cell} + 1) + 2 \cdot N_{ID}^{cell} + N_{CP}$ at the start of each OFDM symbol where <u>LTE Book:</u> Synchronization and Cell Search

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 3	<u>Accused Products (UE)</u>
	7.1 Introduction A User Equipment (UE) wishing to access an LTE cell must first undertake a <i>cell search procedure</i>. This chapter focuses on the aspects of the physical layer that are designed to facilitate cell search. The way this relates to the overall mobility functionality and protocol aspects for cell reselection and handover is explained in Chapters 3 and 22. The performance requirements related to cell search and synchronization are explained in Section 22.2. <u>At the physical layer, the cell search procedure consists of a series of synchronization stages by which the UE determines time and frequency parameters that are necessary to demodulate the downlink and to transmit uplink signals with the correct timing. The UE also acquires some critical system parameters.</u> Three major synchronization requirements can be identified in the LTE system: 1. Symbol and frame timing acquisition, by which the correct symbol start position is determined, for example to set the Discrete Fourier Transform (DFT) window position; 2. Carrier frequency synchronization, which is required to reduce or eliminate the effect of frequency errors¹ arising from a mismatch of the local oscillators between the transmitter and the receiver, as well as the Doppler shift caused by any UE motion; 3. Sampling clock synchronization. (Also discussing the three major synchronization requirements). 7.2 Synchronization Sequences and Cell Search in LTE The cell search procedure in LTE begins with a synchronization procedure which makes use of two specially designed physical signals that are broadcast in each cell: the Primary Synchronization Signal (PSS) and the Secondary Synchronization Signal (SSS). The detection of

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 3	<u>Accused Products (UE)</u>
	these two signals not only enables time and frequency synchronization, but also provides the UE with the physical layer identity of the cell and the cyclic prefix length, and informs the UE whether the cell uses Frequency Division Duplex (FDD) or Time Division Duplex (TDD). In the case of initial synchronization (when the UE is not already camping on or connected to an LTE cell) after detecting the synchronization signals, the UE decodes the Physical Broadcast CHannel (PBCH), from which critical system information is obtained (see Section 9.2.1). In the case of neighbour cell identification, the UE does not need to decode the PBCH; it simply makes quality-level measurements based on the reference signals (see Chapter 8) transmitted from the newly detected cell and uses them for cell reselection (in RRC_IDLE state) or handover (in RRC_CONNECTED state); in the latter case, the UE reports these measurements to its serving cell. The cell search and synchronization procedure is summarized in Figure 7.1, showing the information ascertained by the UE at each stage. The PSS and SSS structure is specifically designed to facilitate this acquisition of information. <pre> graph TD PSS[PSS Detection] --> SSS[SSS Detection] SSS --> RS[RS Detection] SSS --> PBCH[PBCH Decoding] RS --> RS_Info[RSRP/RSRQ measurement and reporting] PBCH --> PBCH_Info[PBCH timing detection
System information access] </pre> The flowchart illustrates the cell search procedure. It starts with PSS Detection, which leads to SSS Detection. From SSS Detection, the process branches into Neighbour cell identification (leading to RS Detection) and Initial synchronization (leading to PBCH Decoding). RS Detection results in RSRP/RSRQ measurement and reporting. PBCH Decoding results in PBCH timing detection and System information access. The initial steps also provide Slot Timing detection and Physical layer ID from PSS, and Radio Frame Timing detection, Cell ID, Cyclic Prefix length detection, and TDD/FDD detection from SSS. Figure 7.1: Information acquired at each step of the cell search procedure. If this element is not literally satisfied by the disclosures cited herein, it is satisfied under the doctrine of equivalents, by the disclosures cited herein because the accused functionality would be insubstantially different from or function in the same way to provide the same result as the relevant claim element.

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 4	<u>Accused Products (UE)</u>
[4] The parameter estimation unit of claim 1, wherein said multi-user detection system includes a tracking unit for acquired signals, and wherein in the presence of a new signal in the acquisition channel of said parameter estimation unit estimates the channel transfer function prior to signal switching from an acquisition channel to the	The Accused 4G UE Instrumentalities include a parameter estimation unit, wherein said multi-user detection system includes a tracking unit for acquired signals, and wherein in the presence of a new signal in the acquisition channel of said parameter estimation unit estimates the channel transfer function prior to signal switching from an acquisition channel to the traffic channel, with said parameter estimation unit parameters being passed to said tracking unit thereafter. For example, LTE uses Synchronization Signal Block (SSB) (“acquisition channel”) to detect the signal transmitted by an eNB, acquire timing, and estimate frequency offset, Doppler, and initial channel parameters to decode the PBCH channel. After synchronization the UE enters idle or connected mode. The synchronization signal identifies the physical-layer cell ID that is further used by the CRS to estimate the channel transfer function. The channel transfer function parameters from the acquisition state are carried over to the next call state of idle or connected mode to track timing, frequency offset, Doppler frequency, and estimated channel parameters. As described above, The Accused 4G UE Instrumentalities need estimates of the channel (“channel transfer function”) between the eNB and the UE to estimate symbols of the multiple users/data streams for interference cancellation/suppression or for data demodulation. Channel estimation is a signal processing task and is to be carried out by a signal processor in the UE. At acquisition time, when a UE selects and acquires the signal transmitted by a base station, the UE needs to acquire and estimate, e.g., system timing, frequency, Doppler and effects of multipaths in the channel. For instance, in an OFDM system, the effects

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 4	<u>Accused Products (UE)</u>
traffic channel, with said parameter estimation unit parameters being passed to said tracking unit thereafter.	of multipath, phases and gains superimposed on the different resource elements (frequency tones), are estimated using reference symbols transmitted by the base stations. Parameters corresponding to timing, frequency offset, Doppler and effects of multipaths are estimated in acquisition state and tracked when on the traffic channel in a connected state. Acquisition and estimation of these parameters is a signal processing function carried out by a signal processing module ("parameter estimation unit"). When the UE transitions from the acquisition state to the connected state a UE channel parameter tracking module ("tracking unit") uses the channel parameters from the acquisition state and tracks these parameters to maintain the call when on the traffic channel. <u>TS 36.211 version 17.1.0:</u> <u>6.11 Synchronization signals</u> There are 504 unique physical-layer cell identities. The physical-layer cell identities are grouped into 168 unique physical-layer cell-identity groups, each group containing three unique identities. The grouping is such that each physical-layer cell identity is part of one and only one physical-layer cell-identity group. <u>A physical-layer cell identity $N_{ID}^{cell} = 3 N_{ID}^{(1)} + N_{ID}^{(2)}$ is thus uniquely defined by a number $N_{ID}^{(1)}$ in the range of 0 to 167, representing the physical-layer cell-identity group, and a number $N_{ID}^{(2)}$ in the range of 0 to 2, representing the physical-layer identity within the physical-layer cell-identity group.</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 4	<u>Accused Products (UE)</u>
	6.10 Reference signals Six types of downlink reference signals are defined: - Cell-specific Reference Signal (CRS) - MBSFN reference signal - UE-specific Reference Signal (DM-RS) associated with PDSCH - DeModulation Reference Signal (DM-RS) associated with EPDCCH or MPDCCH - Positioning Reference Signal (PRS) - CSI Reference Signal (CSI-RS) There is one reference signal transmitted per downlink antenna port. 6.10.1 Cell-specific Reference Signal (CRS) The UE may assume cell-specific reference signals are, unless otherwise stated in [4, clause 12], transmitted in - all downlink subframes for frame structure type 1, - all downlink subframes and DwPTS for frame structure type 2, - non-empty subframes for frame structure type 3 in a cell supporting PDSCH transmission. If special subframe configuration 10 is configured by the higher layer signalling <i>ssp10-CRS-LessDwPTS</i>, the UE cannot assume that cell specific reference signals are transmitted in the 5th OFDM symbol of the special subframe. Cell-specific reference signals are transmitted on one or several of antenna ports 0 to 3. Cell-specific reference signals are transmitted in subframes where $\Delta f = 15$ kHz only.

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 4	<u>Accused Products (UE)</u>
	6.10.1.1 Sequence generation The reference-signal sequence $r_{l,n_s}(m)$ is defined by $r_{l,n_s}(m) = \frac{1}{\sqrt{2}}(1 - 2 \cdot c(2m)) + j \frac{1}{\sqrt{2}}(1 - 2 \cdot c(2m+1)), \quad m = 0, 1, \dots, 2N_{\text{RB}}^{\text{max,DL}} - 1$ where n_s is the slot number within a radio frame and l is the OFDM symbol number within the slot. The pseudo-random sequence $c(i)$ is defined in clause 7.2. The pseudo-random sequence generator shall be initialised with $c_{\text{init}} = 2^{10} \cdot (7 \cdot (n_s' + 1) + l + 1) \cdot (2 \cdot N_{\text{ID}}^{\text{cell}} + 1) + 2 \cdot N_{\text{ID}}^{\text{cell}} + N_{\text{CP}}$ at the start of each OFDM symbol where <u>LTE Book:</u> Synchronization and Cell Search

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 4	<u>Accused Products (UE)</u>
	7.1 Introduction A User Equipment (UE) wishing to access an LTE cell must first undertake a <i>cell search procedure</i>. This chapter focuses on the aspects of the physical layer that are designed to facilitate cell search. The way this relates to the overall mobility functionality and protocol aspects for cell reselection and handover is explained in Chapters 3 and 22. The performance requirements related to cell search and synchronization are explained in Section 22.2. <u>At the physical layer, the cell search procedure consists of a series of synchronization stages by which the UE determines time and frequency parameters that are necessary to demodulate the downlink and to transmit uplink signals with the correct timing. The UE also acquires some critical system parameters.</u> Three major synchronization requirements can be identified in the LTE system: 1. Symbol and frame timing acquisition, by which the correct symbol start position is determined, for example to set the Discrete Fourier Transform (DFT) window position; 2. Carrier frequency synchronization, which is required to reduce or eliminate the effect of frequency errors¹ arising from a mismatch of the local oscillators between the transmitter and the receiver, as well as the Doppler shift caused by any UE motion; 3. Sampling clock synchronization. (Also discussing the three major synchronization requirements). 7.2 Synchronization Sequences and Cell Search in LTE The cell search procedure in LTE begins with a synchronization procedure which makes use of two specially designed physical signals that are broadcast in each cell: the Primary Synchronization Signal (PSS) and the Secondary Synchronization Signal (SSS). The detection of

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 4	<u>Accused Products (UE)</u>
	these two signals not only enables time and frequency synchronization, but also provides the UE with the physical layer identity of the cell and the cyclic prefix length, and informs the UE whether the cell uses Frequency Division Duplex (FDD) or Time Division Duplex (TDD). In the case of initial synchronization (when the UE is not already camping on or connected to an LTE cell) after detecting the synchronization signals, the UE decodes the Physical Broadcast CHannel (PBCH), from which critical system information is obtained (see Section 9.2.1). In the case of neighbour cell identification, the UE does not need to decode the PBCH; it simply makes quality-level measurements based on the reference signals (see Chapter 8) transmitted from the newly detected cell and uses them for cell reselection (in RRC_IDLE state) or handover (in RRC_CONNECTED state); in the latter case, the UE reports these measurements to its serving cell. The cell search and synchronization procedure is summarized in Figure 7.1, showing the information ascertained by the UE at each stage. The PSS and SSS structure is specifically designed to facilitate this acquisition of information. <pre> graph TD PSS[PSS Detection] --> SSS[SSS Detection] SSS --> RS[RS Detection] SSS --> PBCH[PBCH Decoding] RS --> RSInfo[RSRP/RSRQ measurement and reporting] PBCH --> PBCHInfo[PBCH timing detection
System information access] RSInfo --> Neighbour[Neighbour cell identification] PBCHInfo --> Initial[Initial synchronization] </pre> The diagram illustrates the cell search procedure. It starts with PSS Detection, which leads to Slot Timing detection and Physical layer ID. This is followed by SSS Detection, which leads to Radio Frame Timing detection, Cell ID, Cyclic Prefix length detection, and TDD/FDD detection. From SSS Detection, the process branches into two paths: Neighbour cell identification and Initial synchronization. Neighbour cell identification involves RS Detection, which leads to RSRP/RSRQ measurement and reporting. Initial synchronization involves PBCH Decoding, which leads to PBCH timing detection and System information access. Figure 7.1: Information acquired at each step of the cell search procedure. <u>LTE Book:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 4	<u>Accused Products (UE)</u>
	<u>Control Plane Protocols</u> The applicable AS-related procedures largely depend on the Radio Resource Control (RRC) state of the User Equipment (UE), which can be either RRC_IDLE or RRC_CONNECTED. A UE in RRC_IDLE performs cell selection and reselection – in other words, it decides on which cell to camp. The cell (re)selection process takes into account the priority of each applicable frequency of each applicable Radio Access Technology (RAT), the radio link quality and the cell status (i.e. whether a cell is barred or reserved). An RRC_IDLE UE monitors a paging channel to detect incoming calls, and also acquires system information. The System Information (SI) mainly consists of parameters by which the network (E-UTRAN) can control the cell (re)selection process. <u>In RRC_CONNECTED, the E-UTRAN allocates radio resources to the UE to facilitate the transfer of (unicast) data via shared data channels.² To support this operation, the UE monitors an associated control channel³ used to indicate the dynamic allocation of the shared transmission resources in time and frequency.</u> The UE provides the network with reports of its If this element is not literally satisfied by the disclosures cited herein, it is satisfied under the doctrine of equivalents, by the disclosures cited herein because the accused functionality would be insubstantially different from or function in the same way to provide the same result as the relevant claim element.

'505 Claim 5	<u>Accused Products (UE)</u>
[5] The parameter estimation unit of claim 1, and	The Accused 4G UE Instrumentalities include a parameter estimation unit, and further includes a traffic channel, and wherein for said traffic channel phase is tracked without utilization of the estimates from the acquisition channel.

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 5	<u>Accused Products (UE)</u>
further including a traffic channel, and wherein for said traffic channel phase is tracked without utilization of the estimates from the acquisition channel.	For example, LTE uses Synchronization Signal Block (SSB) (“acquisition channel”) to detect the signal transmitted by an eNB, acquire timing, and estimate frequency offset, Doppler, and initial channel parameters for the 72 BPCH Resources Elements (REs) to decode the PBCH information. After synchronization the UE may be assigned a traffic channel (connected mode). In connected mode the UE will be assigned new resource elements from a much larger pool of REs, e.g., 601 REs in a 10 MHz wide frequency channel, whose channel response (e.g., phase) need to be computed and tracked using reference symbols such as CRS symbols associated with the traffic channel assigned resources, once the REs have been assigned to a UE on a traffic channel. As described above, The Accused 4G UE Instrumentalities need estimates of the channel (“channel transfer function”) between the eNB and the UE to estimate symbols of the multiple users/data streams for interference cancellation/suppression or for data demodulation. Channel estimation is a signal processing task and is to be carried out by a signal processor in the UE. At acquisition time, when a UE selects and acquires the signal transmitted by a base station, the UE needs to acquire and estimate, e.g., system timing, frequency, Doppler and effects of multipaths in the channel. For instance, in an OFDM system, the effects of multipath, phases and gains superimposed on the different resource elements (frequency tones), are estimated using reference symbols transmitted by the base stations. Parameters corresponding to timing, frequency offset, Doppler and effects of multipaths are estimated in acquisition state and tracked when on the traffic channel in a connected state. Acquisition and estimation of these parameters is a signal processing function carried out by a signal processing module ("parameter estimation unit"). When the UE

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 5	<u>Accused Products (UE)</u>
	transitions from the acquisition state to the connected state a UE channel parameter tracking module ("tracking unit") uses the channel parameters from the acquisition state and tracks these parameters to maintain the call when on the traffic channel. <u>TS 36.211 version 17.1.0:</u> 6.6 Physical broadcast channel 6.6.4 Mapping to resource elements The block of complex-valued symbols shall be mapped in sequence starting with $y(0)$ to resource elements (k, l) constituting the core set of PBCH resource elements. The mapping to resource elements (k, l) not reserved for transmission of reference signals shall be in increasing order of first the index k, then the index l in slot 1 in subframe 0 and finally the radio frame number. <u>The resource-element indices are given by</u> $k = \frac{N_{RB}^{DL} N_{sc}^{RB}}{2} - 36 + k', \quad k' = 0, 1, \dots, 71$ $l = 0, 1, \dots, 3$ where resource elements reserved for reference signals shall be excluded. The mapping operation shall assume cell-specific reference signals for antenna ports 0-3 being present irrespective of the actual configuration. The UE shall assume that the resource elements assumed to be reserved for reference signals in the mapping operation above but not used for transmission of reference signal are not available for PDSCH or MPDCCH transmission. The UE shall not make any other assumptions about these resource elements. <u>TS 36.211 version 17.1.0:</u>

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3

'505 Claim 5	<u>Accused Products (UE)</u>
	6.6.4.1 PBCH repetition in the cell acquisition subframe For a MBMS-dedicated cell with $N_{RB}^{DL} > 6$, - symbols mapped to core resource element (k, l) in slot 1 in subframe 0 within a radio frame n_f according to the mapping operation in clause 6.6.4, and - cell-specific reference signals in OFDM symbols l in slot 1 in subframe 0 within a radio frame n_f with l according to the mapping operation in clause 6.6.4 shall additionally be multiplied by $\theta_{k,l'}$ and mapped to resource elements (k, l') in slot number n_s' within radio frame n_f where l' and n_s' are given by Table 6.6.4.1-1 in frames fulfilling - $n_f \bmod 4 = 0$ for $25 \leq N_{RB}^{DL}$; - $n_f \bmod 8 = 4$ for $6 < N_{RB}^{DL} < 25$ Resource elements already reserved or used for transmission of cell-specific reference signals in absence of repetition shall not be used for additional mapping of cell-specific reference signals. The quantity $\theta_{k,l'}$ is given by $\theta_{k,l'} = e^{j\pi c(2k')/2} e^{j\pi c(2k'+1)}$ where the relationship between k' and k is defined in clause 6.6.4, and the pseudo-random sequence $c(i)$ is given by clause 7.2 and initialized for each OFDM symbol l' with $c_{init} = 2^{13} \left((N_{ID}^{cell} + 1)(N_{symb}^{DL} n_s' + l' + 1) \right) + 2^4 N_{ID}^{cell} + (N_{symb}^{DL} n_s' + l')$ <u>LTE Downlink Frame Structure:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 5	<u>Accused Products (UE)</u>
	Physical Channels and Signals in Radio Frame Now I will talk about the details of various type of physical channels that will be embedded into the frame structure shown above. The description on this page is just an overview of each physical channels. It is too much to put all the details of each physical channels in single page. I recommend you to use this as a summary (cheat sheet) for each channels and refer to other pages linked under each descriptions if you want to get further details. PBCH(Physical Broadcast Channel) ◦ It carries only the MIB. ◦ It is using QPSK. ◦ <u>Mapped to 6 Resource Blocks (72 subcarriers), centered around DC subcarrier in sub frame 0.</u> ◦ Mapped to Resource Elements which is not reserved for transmission of reference signals, PDCCH or PCHICH ◦ Refer to Physical Layer : PBCH and Matlab Toolbox : PBCH page for the details. If this element is not literally satisfied by the disclosures cited herein, it is satisfied under the doctrine of equivalents, by the disclosures cited herein because the accused functionality would be insubstantially different from or function in the same way to provide the same result as the relevant claim element.
'505 Claim 7	<u>Accused Products (UE)</u>
[7.] The parameter estimation unit of claim 1, wherein after initial estimate generation, said multi-user detection system simultaneously	The Accused 4G UE Instrumentalities include a parameter estimation unit, wherein said multi-user detection system includes a tracking unit for acquired signals, and after initial estimate generation, said multi-user detection system simultaneously tracks all signals in a traffic channel. Once a UE is assigned resources on a traffic channel, the UE must track channel transfer function metrics such as symbol timing, frequency offset, Doppler frequency, and channel response on the frequency resource elements during data transmission.

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 7	<u>Accused Products (UE)</u>
tracks all signals in a traffic channel.	For example, an MMSE, or a variation of MMSE, receiver, used to carry out interference cancellation in a Symbol Level Interference Cancellation (SLIC) scheme needs to maintain synchronization in frequency and time and track changes in the channel response of the resource elements using the reference symbols for the different desired and interfering signals being received at the UE. As described above, The Accused 4G UE Instrumentalities need estimates of the channel (“channel transfer function”) between the eNB and the UE to estimate symbols of the multiple users/data streams for interference cancellation/suppression or for data demodulation. Channel estimation is a signal processing task and is to be carried out by a signal processor in the UE. At acquisition time, when a UE selects and acquires the signal transmitted by a base station, the UE needs to acquire and estimate, e.g., system timing, frequency, Doppler and effects of multipaths in the channel. For instance, in an OFDM system, the effects of multipath, phases and gains superimposed on the different resource elements (frequency tones), are estimated using reference symbols transmitted by the base stations. Parameters corresponding to timing, frequency offset, Doppler and effects of multipaths are estimated in acquisition state and tracked when on the traffic channel in a connected state. Acquisition and estimation of these parameters is a signal processing function carried out by a signal processing module ("parameter estimation unit"). When the UE transitions from the acquisition state to the connected state a UE channel parameter tracking module ("tracking unit") uses the channel parameters from the acquisition state and tracks these parameters to maintain the call when on the traffic channel. <u>3GPP TR 36.866 V12.0.1:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 7	<u>Accused Products (UE)</u>
	9.1.5.2 Alternative 2 Generally, the system level modelling methodology for SLIC is carried out by two steps. The first step is to derive the post-processing SINR per subcarrier. After that, the simulator predicts the instantaneous BLER for each transmission block by a link quality model (such as MIESM,EESM etc.) based on the input SINRs. Here, we will only focuses on how to obtaining of post-processing SINRs. For simplicity, we assume the target UE eliminates the strongest interference, and only one layer is transmitted for both target UE and interfering UE. The received downlink signal for each subcarrier can be written as $y = \underline{H_z} x_z + \underline{H_1} x_1 + \sum_{k=2}^{N-1} \underline{H_k} x_k + n \quad (9.47)$ <u>Where H_1 denotes the effective channel from the strongest interfering cell to the target UE and x_1 denotes the strongest interfering symbol.</u> In the first place, the strongest interference signal is detected with its corresponding post-processed SINR, take MMSE receiver as an example, $\gamma_{MMSE-1st-inf} = w_{MMSE-1st-inf} \cdot \tilde{H}_1 / (1 - w_{MMSE-1st-inf} \cdot \tilde{H}_1) \quad (9.48)$ where $w_{MMSE-1st-inf} = \tilde{H}_1^H \left(\underline{\tilde{H}_1} \underline{\tilde{H}_1}^H + diag \left(\underline{\tilde{H}_z} \underline{\tilde{H}_z}^H + \sum_{k=2}^{N-1} \underline{\tilde{H}_k} \underline{\tilde{H}_k}^H + \sigma_N^2 \cdot I \right) \right)^{-1} \quad (9.49)$

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 7	<u>Accused Products (UE)</u>
	Once the strongest interference signal is detected, it could be removed from the received signal. However, the strongest interference signal cannot be completely removed in practical system. Let e_k denotes the residual error and $\bar{\sigma}$ be the variance of demodulated symbols residual error, $e = \tilde{H}_1 x_1 - \tilde{H}_1 \tilde{x}_1 = \tilde{H}_1 (x_1 - \tilde{x}_1), \quad \bar{\sigma} = \frac{1}{L} \sum_{l=1}^L \ x_{1l} - \tilde{x}_{1l}\ ^2, \quad (9.50)$ where L is the number of trials. If this element is not literally satisfied by the disclosures cited herein, it is satisfied under the doctrine of equivalents, by the disclosures cited herein because the accused functionality would be insubstantially different from or function in the same way to provide the same result as the relevant claim element.

'505 Claim 8	<u>Accused Products (UE)</u>
[8.] The parameter estimation unit of claim 7, wherein said simultaneous tracking includes blocks for parallel recreation of the training signal	The Accused 4G UE Instrumentalities include a parameter estimation unit, wherein said simultaneous tracking includes blocks for parallel recreation of the training signal portions of the traffic channel signal, each parallel processing block isolating a different signal in said traffic channel. For example, in iterative channel estimation and CRS interference cancellation of colliding CRS scenario the receiver to improve the channel estimate accuracy channel estimation and CRS cancellation is carried out for the colliding CRS symbols of the serving and interfering cells in parallel.

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 8	<u>Accused Products (UE)</u>
portions of the traffic channel signal, each parallel processing block isolating a different signal in said traffic channel.	As described above, The Accused 4G UE Instrumentalities need estimates of the channel (“channel transfer function”) between the eNB and the UE to estimate symbols of the multiple users/data streams for interference cancellation/suppression or for data demodulation. Channel estimation is a signal processing task and is to be carried out by a signal processor in the UE. At acquisition time, when a UE selects and acquires the signal transmitted by a base station, the UE needs to acquire and estimate, e.g., system timing, frequency, Doppler and effects of multipaths in the channel. For instance, in an OFDM system, the effects of multipath, phases and gains superimposed on the different resource elements (frequency tones), are estimated using reference symbols transmitted by the base stations. Parameters corresponding to timing, frequency offset, Doppler and effects of multipaths are estimated in acquisition state and tracked when on the traffic channel in a connected state. Acquisition and estimation of these parameters is a signal processing function carried out by a signal processing module ("parameter estimation unit"). When the UE transitions from the acquisition state to the connected state a UE channel parameter tracking module ("tracking unit") uses the channel parameters from the acquisition state and tracks these parameters to maintain the call when on the traffic channel. <u>Qualcomm’s ’915 patent:</u> <i>“FIG. 6A is a block diagram conceptually illustrating a colliding CRS scenario before interference cancellation is performed, according to one aspect of the present disclosure. In FIG. 6A, the horizontal axes represent frequency. Reference signal (e.g., CRS) tones and control/data tones are shown for a Sub carrier of a neighbor cell and a serving cell. As shown in FIG. 6A, serving cell CRS tones see interference</i>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

'505 Claim 8	<u>Accused Products (UE)</u>
	<i>from the CRS tones of the neighbor cell. To improve interference cancellation results, according to one aspect the UE decouples CRS interference cancellation and control/data channel interference cancellation in a colliding CRS tone scenario. That is, the UE first performs CRS interference cancellation to estimate the serving cell channels and then proceeds with neighbor cell and serving cell control/data channel interference cancellation and decoding.” [Col.12, Lines 63 – Col.13, Lines 10]</i> <i>“In one example, the UE performs the decoupled interference cancellation/channel estimation process as described above based on CRS tones and/or DRS tones according to the following order (e.g., when the neighboring cell is stronger):</i> <i>1. Neighbor cell channel estimation:</i> <i>2. Neighbor cell CRS interference cancellation and/or neighbor cell DRS interference cancellation;</i> <i>3. Serving cell channel estimation;</i> <i>4. For iterative interference cancellation (e.g., when the cells are of similar strength), perform serving cell CRS interference cancellation and/or perform serving cell DRS interference cancellation and repeat 1-4 a number of times in a well-known manner.</i> <i>5. Neighbor cell control/data channel decoding:</i> <i>6. Neighbor cell control/data channel interference cancellation;</i>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

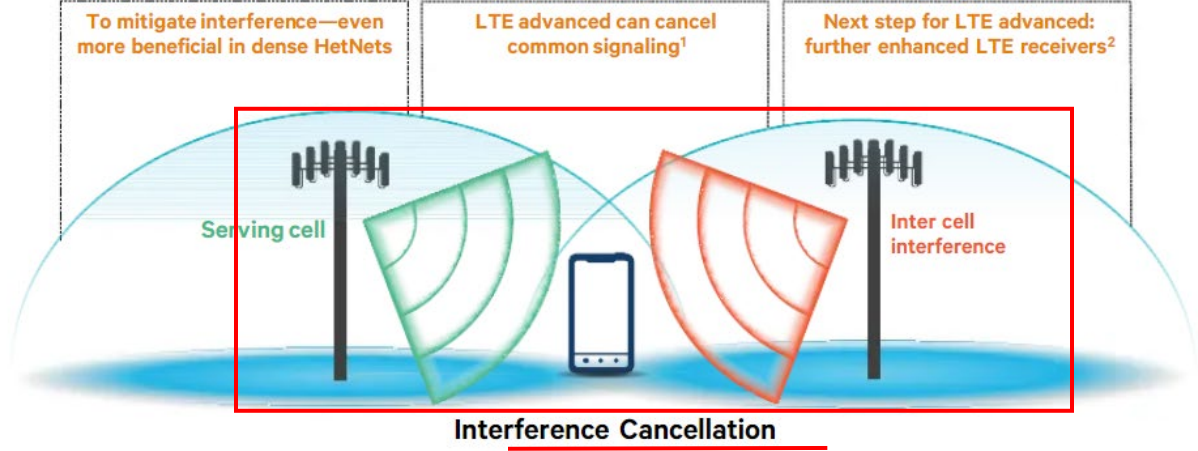
'505 Claim 8	<u>Accused Products (UE)</u>
	7. <i>Serving cell control/data channel decoding:</i> 8. <i>For iterative interference cancellation (e.g., when the cells are of similar strength), perform serving cell control/data channel interference cancellation and repeat 5-8 a number of times in a well-known manner.</i> .” [Col.13, Lines 58 – Col.14, Lines 11] <i>“The approach of FIGS. 8-10 also works for a colliding CRS scenario and/or a colliding DRS Scenario, but the approach of FIGS. 6 and 7 may be selected for colliding CRS scenarios and/or colliding DRS scenarios for one or more reasons. It is generally the case that the approach of FIGS. 8-10 has a higher complexity than the approach of FIGS. 6 and 7. Furthermore, if an iterative interference cancellation approach is employed in a colliding CRS scenario and/or a colliding DRS scenario, it may be advantageous to use the approach of FIGS. 6 and 7 to reduce the number of iterations in control/data channel interference cancellation. Specifically, in an iterative approach of FIGS. 6 and 7, the control/data channel decoding on the serving and neighbor cells are performed with the final channel estimates that are obtained after all the CRS and/or DRS interference cancellation iterations are completed, whereas in an iterative approach according to FIGS. 8-10, the control/data channel decoding of the serving and neighbor cells are performed with intermediate channel estimates that are available on the given iteration. Because the intermediate channel estimates are less accurate than the final channel estimates, it is desirable to implement more iterations for the approach according to FIGS. 8-10 than for the approach according to FIGS. 6-7.” [Col.15, Lines 59-67 – Col.16, Lines 1-14]</i>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

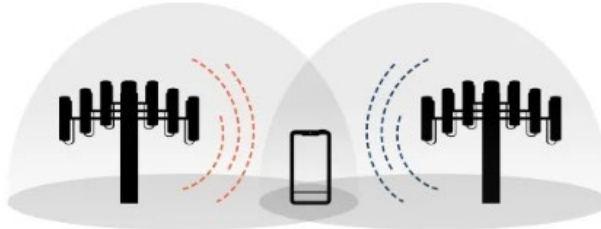
'505 Claim 8	<u>Accused Products (UE)</u>
	If this element is not literally satisfied by the disclosures cited herein, it is satisfied under the doctrine of equivalents, by the disclosures cited herein because the accused functionality would be insubstantially different from or function in the same way to provide the same result as the relevant claim element.

U.S. 6,947,505 Claim 9	Accused Products
[9.pre] In a multi-user detection system in which interfering signals are purposely allowed to exist, a parameter estimation unit for use in conjunction with a signal separation unit for estimating channel transfer function	To the extent the preamble is found to be limiting, the Accused 4G UE Instrumentalities operate in a multi-user detection system in which interfering signals are purposely allowed to exist and include a parameter estimation unit for using in conjunction with a signal separation unit, in which each received signal has associated channel transfer functions. The Accused 4G UE Instrumentalities are capable of receiving signals or streams from multiple cells, where each received signal/stream is for a user. CRS is the downlink reference signal transmitted over Almost Blank Subframes (ABSF). CRSs (i.e., the reference signal received by the UE from an eNB) are primarily used for channel transfer function estimation. They estimate the channel transfer function of the multipath propagation channel to estimate interfering symbols prior to interference cancellation, suppression. When reference symbols of different cells arrive at the same time, i.e., collide, an iterative channel estimation that reconstructs the interfering reference symbol using the available channel estimates, cancels the interfering reference symbol, and updates channel estimates, is used to improve channel transfer function. The different parameters of the received reference signal are also estimated.

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
parameters from channel transfer functions, comprising:	<u>Qualcomm LTE-Advanced Presentation:</u> HetNets: next generation advanced receivers  ¹Performance requirement added to 3GPP for cancellation of common signaling (PSS/SSS/PBCH/CRS) in Rel 10/11. ²Broad study on UE interference suppression with & without network assistance in 3GPP R12 <u>Qualcomm LTE Advanced - Evolving and expanding into new frontiers Presentation:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products															
	Enhanced receivers offer better user experience & more capacity Interference Cancellation  <table><thead><tr><th>Interference Cancellation</th><th>Rel. 10/11</th><th>Re. 12</th></tr></thead><tbody><tr><td>Sync ref. signal</td><td>✓</td><td>✓</td></tr><tr><td>Common ref. signal</td><td>✓</td><td>✓</td></tr><tr><td>Primary broadcast channel</td><td>✓</td><td>✓</td></tr><tr><td>Data channel</td><td></td><td>✓</td></tr></tbody></table> Better user experience - Higher data rates especially at cell-edges Higher network capacity - Higher users data rate increases overall network capacity Enhanced performance for HetNets - Even more beneficial in managing interference in small cell deployments	Interference Cancellation	Rel. 10/11	Re. 12	Sync ref. signal	✓	✓	Common ref. signal	✓	✓	Primary broadcast channel	✓	✓	Data channel		✓
Interference Cancellation	Rel. 10/11	Re. 12														
Sync ref. signal	✓	✓														
Common ref. signal	✓	✓														
Primary broadcast channel	✓	✓														
Data channel		✓														

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	Interference Management QUALCOMM • Advanced receivers – <u>Mitigate interference from broadcast signals and channels transmitted to support legacy UEs</u> – Exploit successive interference cancellation principle • Detect, decode and cancel strong interferer • Continue until desired signal can be decoded – Fully feasible for signals and channels that are broadcasted at full power • If it cannot be decoded, interference is weak and can be ignored – Not always feasible for unicast data channels • Modulation and coding is selected targeting desired user

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	 Interference Management • <i>Advanced receivers</i> – Rel 10 UEs employing advanced receivers enjoy full potential benefits of range expansion • Synchronization signals (PSS/SSS) interference cancellation – Essential for cell acquisition – known signal broadcast at full power – Need to estimate the channel before cancellation is performed • Primary broadcast channel (PBCH) interference cancellation – Essential for cell acquisition – broadcast at full power – Use decode and cancel principle – Need to estimate the channel before cancellation is performed • <u>Common reference signal (CRS) interference cancellation</u> – Known signal broadcast at full power – <u>Strong CRS interference removed</u> – <u>Essential for decoding of DL control and data channels (PDCCH/PDSCH) and accurate RRM measurements and channel feedback for range expansion UEs</u> – <u>Need to estimate the channel before cancellation is performed</u> <u>Verizon Wireless Requirements Plan:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	<u>1.3.2.20 LTE R10 eICIC and CRS IC w/o ABS (Enhanced Inter-Cell Interference Cancellation)</u> VZ_REQ_LTEB13NAC_36948 Applicable scenarios: • Heterogeneous network that has both small/pico cells and macro cells deployed • R10 eICIC is used to enable network to perform necessary interference management by configuring ABS subframe dynamically. • Macro homogeneous network & Heterogeneous network • CRS IC is used in macro network in non-ABS scenario • Improve PDCCH and PDSCH performance in non-colliding CRS case (user throughput) • Improve RSRP accuracy and channel estimation in colliding CRS case (improved CRS SINR and as a result better performance on PBCH and PSS/SSS) Note: UE shall not advertise any of the CRS IC and/or eICIC capability until "service enablement" direction is received from Verizon Device Marketing. (e.g., FGI115, crs-InterfHandl-r11). <u>Qualcomm Heterogeneous Network:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	For time-domain resource partitioning, a macro base-station can use almost blank subframes (ABSF) to reserve some subframes for picos. The macro base-station keeps transmitting legacy common control channels during ABSFs to enable full backward compatibility with legacy user terminals. <u>The user terminals can cancel interference on common control channels of ABSF caused either by higher power macro stations or by close-by femto stations that the user terminals are prohibited to access. The function of the advanced receiver is illustrated in Figure 6. The interference cancellation receiver fully handles colliding and non-colliding Reference Signal (RS) scenarios and removes the need for cell planning of heterogeneous deployment.</u> Almost-blank subframe from interfering base-station Residual interference at UE: "blank" subframe  <pre> graph LR A[Almost-blank subframe from interfering base-station] --> B[Enhanced UE Receiver] B --> C[Residual interference at UE: "blank" subframe] </pre> [Figure 6] Advanced user equipment (UE) receiver cancels the reference signal in "almost-blank" subframes from interfering base-stations

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products																																	
	<u>TSG-RAN WG4, Contribution # R4-126146:</u> Title: Discussion on the framework of FeICIC demodulation and CSI testing 3.2 CRS configuration The other important assumption is whether colliding CRS or non-colliding CRS are configured between Pico cell and Macro cells. Assuming that there are two strong aggressor cells, the possible CRS configurations are listed in Table 1. Table 1: Possible CRS configurations for FeICIC [8] <table><tr><th rowspan="2">Case #</th><th rowspan="2">Descriptions</th><th colspan="3">Cell ID (example)</th></tr><tr><th>S</th><th>SI</th><th>WI</th></tr><tr><td>Case 1</td><td>[(S,SI), (S,WI), (SI, WI)] = [C, C, C]</td><td>1</td><td>7</td><td>13</td></tr><tr><td>Case 2</td><td>[(S,SI), (S,WI), (SI, WI)] = [N, N, C]</td><td>1</td><td>2</td><td>8</td></tr><tr><td>Case 3</td><td>[(S,SI), (S,WI), (SI, WI)] = [N, N, N]</td><td>1</td><td>2</td><td>3</td></tr><tr><td>Case 4</td><td>[(S,SI), (S,WI), (SI, WI)] = [C, N, N]</td><td>1</td><td>7</td><td>2</td></tr><tr><td>Case 5</td><td>[(S,SI), (S,WI), (SI, WI)] = [N, C, N]</td><td>1</td><td>2</td><td>7</td></tr></table> “C”: CRS collision; “N”: CRS non-collision; “S”: Serving cell; “SI”: Stronger Interferer; “WI”: Weaker Interferer. In [3] the <i>first aggressor with colliding CRS and the second aggressor with non-colliding CRS</i> were assumed. In [4] it was proposed that <i>both colliding CRS and non-colliding CRS</i> were configured, and <i>CSI test for colliding CRS case shall be introduced and CSI test for non-colliding CRS case is FFS</i>. And according to RRM discussion in the last meeting, the company also propose the assumption of the first aggressor with non-colliding CRS and the second one with colliding CRS. The CRS configuration assumptions will impact the UE implementations and performances. The CRS colliding case fails the puncturing receiver and requires the serial CRS-cancelling to achieve the good channel estimation and other measurements for the serving cell, which needs the relatively long processing time. On the contrary, the CRS non-colliding case allows the UE to cancel the interferences parallel and makes the puncturing receiver feasible. From the implementation aspect, Case 1 is more demanding. From the performance point of view, the performance at high serving cell SNR is more sensitive to the data region interference from the aggressor cells although the interference level is relatively low. The UE’s support of interference handling for CRS is indicated by the parameter <i>crs-InterfHandl</i> whereas <i>ss-CCH-InterfHandl</i> indicates support for synchronization signal and common	Case #	Descriptions	Cell ID (example)			S	SI	WI	Case 1	[(S,SI), (S,WI), (SI, WI)] = [C, C, C]	1	7	13	Case 2	[(S,SI), (S,WI), (SI, WI)] = [N, N, C]	1	2	8	Case 3	[(S,SI), (S,WI), (SI, WI)] = [N, N, N]	1	2	3	Case 4	[(S,SI), (S,WI), (SI, WI)] = [C, N, N]	1	7	2	Case 5	[(S,SI), (S,WI), (SI, WI)] = [N, C, N]	1	2	7
Case #	Descriptions			Cell ID (example)																														
		S	SI	WI																														
Case 1	[(S,SI), (S,WI), (SI, WI)] = [C, C, C]	1	7	13																														
Case 2	[(S,SI), (S,WI), (SI, WI)] = [N, N, C]	1	2	8																														
Case 3	[(S,SI), (S,WI), (SI, WI)] = [N, N, N]	1	2	3																														
Case 4	[(S,SI), (S,WI), (SI, WI)] = [C, N, N]	1	7	2																														
Case 5	[(S,SI), (S,WI), (SI, WI)] = [N, C, N]	1	2	7																														

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	channel interference handling. The eNB may send <i>CRS assistance information</i> of the aggressor cells to the UE to aid the UE to mitigate the interference from CRS of the aggressor cells. <i>RadioResourceConfigDedicated</i> may optionally include <i>neighCellsCRS-Info-r11</i> which is used to send <i>CRS assistance information</i> of one or several aggressor cells as shown in the figure below. <u>TS 36.331 version 17.0.0</u> <pre> CRS-AssistanceInfoList-r11 ::= SEQUENCE (SIZE (1..maxCellReport)) OF CRS-AssistanceInfo-r11 CRS-AssistanceInfo-r11 ::= SEQUENCE { physCellId-r11 PhysCellId, antennaPortsCount-r11 ENUMERATED {an1, an2, an4, spare1}, mbsfn-SubframeConfigList-r11 MBSFN-SubframeConfigList, ..., [[mbsfn-SubframeConfigList-v1430 MBSFN-SubframeConfigList-v1430 OPTIONAL -- Need ON]] } </pre> <pre> PhyLayerParameters-v1130 ::= SEQUENCE { crs-InterfHandl-r11 ENUMERATED {supported} OPTIONAL, ePDCCCH-r11 ENUMERATED {supported} OPTIONAL, multiACK-CSI-Reporting-r11 ENUMERATED {supported} OPTIONAL, ss-CCH-InterfHandl-r11 ENUMERATED {supported} OPTIONAL, tdd-SpecialSubframe-r11 ENUMERATED {supported} OPTIONAL, txDiv-PUCCH1b-ChSelect-r11 ENUMERATED {supported} OPTIONAL, ul-CoMP-r11 ENUMERATED {supported} OPTIONAL } </pre>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	<i>neighCellsCRS-Info, neighCellsCRS-InfoSCell, neighCellsCRS-InfoPSCell</i> This field contains assistance information used by the UE to mitigate interference from CRS while performing RRM/RLM/CSI measurement or data demodulation or DL control channel demodulation. When the received CRS assistance information is for a cell with CRS non-colliding with that of the CRS of the cell to measure, the UE may use the CRS assistance information to mitigate CRS interference. When the received CRS assistance information is for a cell with CRS colliding with that of the CRS of the cell to measure, the UE may use the CRS assistance information to mitigate CRS interference RRM/RLM (as specified in TS 36.133 [16]) and for CSI (as specified in TS 36.101 [42]) on the subframes indicated by <i>measSubframePatternPCell</i>, <i>measSubframePatternConfigNeigh</i>, <i>csi-MeasSubframeSet1</i> if configured, and the CSI subframe set 1 if <i>csi-MeasSubframeSets-r12</i> is configured. The UE may use CRS assistance information to mitigate CRS interference from the cells in the <i>CRS-AssistanceInfoList</i> for the demodulation purpose or DL control channel demodulation as specified in TS 36.101 [42]. EUTRAN does not configure <i>neighCellsCRS-Info-r11</i> or <i>neighCellsCRS-Info-r13</i> if <i>eimta-MainConfigPCell-r12</i> is configured. <u>TS 36.211 version 17.1.0:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	6.10 Reference signals Six types of downlink reference signals are defined: - Cell-specific Reference Signal (CRS) - MBSFN reference signal - UE-specific Reference Signal (DM-RS) associated with PDSCH - DeModulation Reference Signal (DM-RS) associated with EPDCCH or MPDCCH - Positioning Reference Signal (PRS) - CSI Reference Signal (CSI-RS) There is one reference signal transmitted per downlink antenna port. 6.10.1 Cell-specific Reference Signal (CRS) The UE may assume cell-specific reference signals are, unless otherwise stated in [4, clause 12], transmitted in - all downlink subframes for frame structure type 1, - all downlink subframes and DwPTS for frame structure type 2, - non-empty subframes for frame structure type 3 in a cell supporting PDSCH transmission. If special subframe configuration 10 is configured by the higher layer signalling <i>ssp10-CRS-LessDwPTS</i>, the UE cannot assume that cell specific reference signals are transmitted in the 5th OFDM symbol of the special subframe. Cell-specific reference signals are transmitted on one or several of antenna ports 0 to 3. Cell-specific reference signals are transmitted in subframes where $\Delta f = 15$ kHz only.

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	6.10.1.1 Sequence generation The reference-signal sequence $r_{l,n_s}(m)$ is defined by $r_{l,n_s}(m) = \frac{1}{\sqrt{2}}(1 - 2 \cdot c(2m)) + j \frac{1}{\sqrt{2}}(1 - 2 \cdot c(2m+1)), \quad m = 0, 1, \dots, 2N_{RB}^{\max, DL} - 1$ where n_s is the slot number within a radio frame and l is the OFDM symbol number within the slot. The pseudo-random sequence $c(i)$ is defined in clause 7.2. The pseudo-random sequence generator shall be initialised with $c_{init} = 2^{10} \cdot (7 \cdot (n'_s + 1) + l + 1) \cdot (2 \cdot N_{ID}^{cell} + 1) + 2 \cdot N_{ID}^{cell} + N_{CP}$ at the start of each OFDM symbol where <u>TSG-RAN WG1, Contribution # R4-121447:</u> 2.1. FeICIC Baseline Receiver Assumptions We start to define the baseline receivers in more detail by describing them verbally. • A CRS puncturing receiver is any kind of receiver that punctures REs of the wanted signal of the serving cell that are heavily interfered by CRS REs received from one or more dominant interfering cells. Knowledge of the CRS

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	REs of the interfering cell(s) is assumed. Obviously, the punctured REs cannot be CRS REs of the serving cell. Hence, the CRS puncturing receiver not applicable in scenarios with colliding CRS. Transmitter side solutions, e.g. PDSCH muting corresponding to the CRS patterns of neighbor cells, are not considered as part of a CRS puncturing receiver. A CRS puncturing receiver is principally applicable to e.g. PDSCH and PDCCH with non-colliding CRS. • A CRS canceling receiver is any kind of receiver that cancels CRS REs received from one or more dominant interfering cells from the wanted signal of the serving cell. Knowledge of the CRS REs of the interfering cell(s) is assumed. Canceling CRS REs from the wanted signal requires channel estimation of the channel from the UE to interfering cell. The wanted signal can be any kind of channel sent by the serving cell including PDSCH, PDCCH, serving cell CRS, etc. Hence, CRS canceling receivers can be applied both in scenarios with colliding and non-colliding CRS. A CRS cancelling receiver is principally applicable to e.g. PDSCH and PDCCH. Figure 1 outlines the basic processing flow in the base line receiver consisting of channel estimation, CRS puncturing/cancelling, MMSE based demodulation, e.g. for PDSCH, and decoding. Derivations from this processing flow are implementation specific and do not need to be defined for the base line receiver.  <pre> graph LR A[Channel Estimation] --> B[CRS puncturing or canceling] B --> C[PDSCH Demodulation (MMSE)] C --> D[Decoding] </pre> Figure 1: Basic Receiver Diagram for PDSCH

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	According to the description for CRS canceling receivers above it needs to be distinguished between colliding and non-colliding CRS. Considering one RE only, the CRS IC system model for both cases can be written in a simplified way as: $\text{CRS IC for colliding CRS : } y_p = h_1 \cdot x_p^{(1)} + h_2 \cdot x_p^{(2)} + n \Rightarrow y_p - \hat{h}_2 \cdot x_p^{(2)}$ $\text{CRS IC for non-colliding CRS : } y_d = h_1 \cdot x_d^{(1)} + h_2 \cdot x_p^{(2)} + n \Rightarrow y_d - \hat{h}_2 \cdot x_p^{(2)}$ Here h_1 and h_2 denote the serving and interfering channel vector (matrix) and $x_p^{(i)}$ and $x_d^{(i)}$, respectively, represent pilot and data symbols, where $i = 1$ indicates the serving cell. y_p and y_d are the received REs. In both cases the interfering channel is estimated and $\hat{h}_2 \cdot x_p^{(2)}$ is subtracted from y_p and y_d. It is seen that in case of colliding CRS canceling interfering CRS mainly aims to improve channel estimation performance of the serving cell whereas in case of non-colliding CRS canceling interfering CRS aims to improve directly e.g. PDSCH and PDCCH performance. In this case channel estimation performance in the serving cell is not improved as long as no iterative receiver is applied. The RAN1 LS [1] states that both colliding and non-colliding CRS scenarios should be considered. As already mentioned, a puncturing receiver is not applicable to non-MBSFN/MBSFN ABS with colliding CRS, whereas a CRS canceling receiver can be applied both to colliding and non-colliding CRS scenarios. Hence, a CRS canceling receiver should be assumed as baseline for colliding CRS both in MBSFN and non-MBSFN ABS. <u>Qualcomm's '915 patent:</u> <i>“Certain channels, most notably Common Reference Signal (CRS) tones and/or DRS tones, have a known sequence. Thus, the channel of the cell to be cancelled can be estimated based on the CRS tones or DRS tones. For example, the UE uses the CRS and/or DRS tones transmitted from an eNB to obtain estimates of the channels between the eNB and the UE. The UE then reconstructs the CRS tones or DRS tones based on the channel estimates and the known sequence, and can cells out the CRS tones or DRS tones. In this document, the CRS and/or the DRS reconstruction and cancellation procedure is referred to as “RS interference cancellation.” Control channels (PBCH, PCFICH, PHICH, PDCCH, R-PHICH (relay-PHICH), R-PDCCH (relay-PDCCH), and the like) and some data channels (PDSCH, R-PDSCH (relay</i>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	<i>PD SCH), and the like) have unknown payloads. For control channels and data channels that do not carry a Dedicated Reference Signal (DRS) tones (e.g., Demodulation Reference Signal (DMRS) tones), the UE relies on the channel estimates obtained from the CRS tones to decode, re-encode, reconstruct, and cancel out the channels. For control channels and data channels that have embedded DRS tones (e.g., Demodulation Reference Signal (DMRS) tones), the UE may rely on the channel estimates obtained from the DRS tones (e.g., Demodulation Reference Signal (DMRS) tones) to decode, re-encode, reconstruct, and cancel out the channels. Whether to use a CRS tones or a DRS tones (e.g., Demodulation Reference Signal (DMRS) tones) to obtain a channel estimate may be based at least in part on a type of the channel, transmission mode, and/or other parameters. For example, the Dedicated Reference Signal (DRS) tones may be transmitted for each channel based at least in part on a request. For example, as described above, DRS tones may be imbedded in a same resource block with the control/data channels in order to obtain a channel estimate of a corresponding channel. In this document, the control and/or data channel re-encoding, reconstruction, and cancellation procedure is referred to as “control/data channel interference cancellation’.” [Col.11, Lines 52-67 – Col.12, Lines 1-21]</i> <i>See also Claim 1, supra.</i>
[9.a] a signal processor for determining said channel transfer	The Accused 4G UE Instrumentalities include a signal processor for determining said channel transfer functions for each received signal. The Accused 4G UE Instrumentalities need estimates of the channel (“channel transfer function”) between the eNB and the UE to estimate symbols of the multiple users/data streams for interference

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
functions for each received signal; and	cancellation/suppression or for data demodulation. Channel estimation is a signal processing task and is to be carried out by a signal processor in the UE. As described above, The Accused 4G UE Instrumentalities need estimates of the channel (“channel transfer function”) between the eNB and the UE to estimate symbols of the multiple users/data streams for interference cancellation/suppression or for data demodulation. Channel estimation is a signal processing task and is to be carried out by a signal processor in the UE. At acquisition time, when a UE selects and acquires the signal transmitted by a base station, the UE needs to acquire and estimate, e.g., system timing, frequency, Doppler and effects of multipaths in the channel. For instance, in an OFDM system, the effects of multipath, phases and gains superimposed on the different resource elements (frequency tones), are estimated using reference symbols transmitted by the base stations. Parameters corresponding to timing, frequency offset, Doppler and effects of multipaths are estimated in acquisition state and tracked when on the traffic channel in a connected state. Acquisition and estimation of these parameters is a signal processing function carried out by a signal processing module ("parameter estimation unit"). When the UE transitions from the acquisition state to the connected state a UE channel parameter tracking module ("tracking unit") uses the channel parameters from the acquisition state and tracks these parameters to maintain the call when on the traffic channel. <u>TSG-RAN WG1, Contribution # R4-121447:</u>

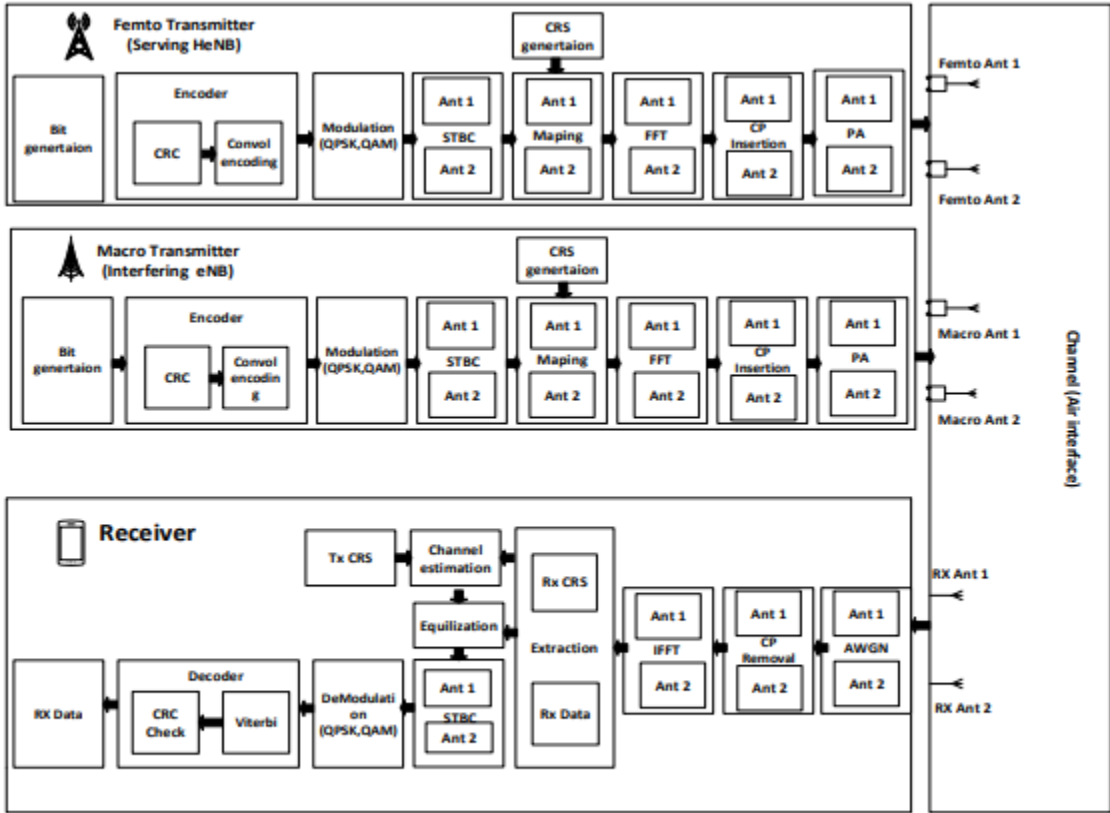
**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	2.1. FeICIC Baseline Receiver Assumptions We start to define the baseline receivers in more detail by describing them verbally. • A CRS puncturing receiver is any kind of receiver that punctures REs of the wanted signal of the serving cell that are heavily interfered by CRS REs received from one or more dominant interfering cells. Knowledge of the CRS REs of the interfering cell(s) is assumed. Obviously, the punctured REs cannot be CRS REs of the serving cell. Hence, the CRS puncturing receiver not applicable in scenarios with colliding CRS. Transmitter side solutions, e.g. PDSCH muting corresponding to the CRS patterns of neighbor cells, are not considered as part of a CRS puncturing receiver. A CRS puncturing receiver is principally applicable to e.g. PDSCH and PDCCH with non-colliding CRS. • A CRS canceling receiver is any kind of receiver that cancels CRS REs received from one or more dominant interfering cells from the wanted signal of the serving cell. Knowledge of the CRS REs of the interfering cell(s) is assumed. Canceling CRS REs from the wanted signal requires channel estimation of the channel from the UE to interfering cell. The wanted signal can be any kind of channel sent by the serving cell including PDSCH, PDCCH, serving cell CRS, etc. Hence, CRS canceling receivers can be applied both in scenarios with colliding and non-colliding CRS. A CRS cancelling receiver is principally applicable to e.g. PDSCH and PDCCH. Figure 1 outlines the basic processing flow in the base line receiver consisting of channel estimation, CRS puncturing/canceling, MMSE based demodulation, e.g. for PDSCH, and decoding. Derivations from this processing flow are implementation specific and do not need to be defined for the base line receiver. <pre> graph LR A[Channel Estimation] --> B[CRS puncturing or canceling] B --> C[PDSCH Demodulation (MMSE)] C --> D[Decoding] </pre> Figure 1: Basic Receiver Diagram for PDSCH

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	According to the description for CRS canceling receivers above it needs to be distinguished between colliding and non-colliding CRS. Considering one RE only, the CRS IC system model for both cases can be written in a simplified way as: $\text{CRS IC for colliding CRS : } \mathbf{y}_p = \mathbf{h}_1 \cdot \mathbf{x}_p^{(1)} + \mathbf{h}_2 \cdot \mathbf{x}_p^{(2)} + \mathbf{n} \Rightarrow \mathbf{y}_p - \hat{\mathbf{h}}_2 \cdot \mathbf{x}_p^{(2)}$ $\text{CRS IC for non-colliding CRS : } \mathbf{y}_d = \mathbf{h}_1 \cdot \mathbf{x}_d^{(1)} + \mathbf{h}_2 \cdot \mathbf{x}_p^{(2)} + \mathbf{n} \Rightarrow \mathbf{y}_d - \hat{\mathbf{h}}_2 \cdot \mathbf{x}_p^{(2)}$ Here $\mathbf{h}_1$ and $\mathbf{h}_2$ denote the serving and interfering channel vector (matrix) and $\mathbf{x}_p^{(i)}$ and $\mathbf{x}_d^{(i)}$, respectively, represent pilot and data symbols, where $i = 1$ indicates the serving cell. $\mathbf{y}_p$ and $\mathbf{y}_d$ are the received REs. In both cases the interfering channel is estimated and $\hat{\mathbf{h}}_2 \cdot \mathbf{x}_p^{(2)}$ is subtracted from $\mathbf{y}_p$ and $\mathbf{y}_d$. It is seen that in case of colliding CRS canceling interfering CRS mainly aims to improve channel estimation performance of the serving cell whereas in case of non-colliding CRS canceling interfering CRS aims to improve directly e.g. PDSCH and PDCCH performance. In this case channel estimation performance in the serving cell is not improved as long as no iterative receiver is applied. The RAN1 LS [1] states that both colliding and non-colliding CRS scenarios should be considered. As already mentioned, a puncturing receiver is not applicable to non-MBSFN/MBSFN ABS with colliding CRS, whereas a CRS canceling receiver can be applied both to colliding and non-colliding CRS scenarios. Hence, a CRS canceling receiver should be assumed as baseline for colliding CRS both in MBSFN and non-MBSFN ABS. <u>Understanding ICI in LTE HetNet, Thesis:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	 The diagram illustrates a system model for a femto network. It consists of three main components: a Femto Transmitter (Serving HeNB), a Macro Transmitter (Interfering eNB), and a Receiver. Femto Transmitter (Serving HeNB): This block includes a Bit generation section, an Encoder (comprising CRC and Convolutional encoding), a Modulation (QPSK, QAM) block, and a CRS generation block. The data path flows through STBC, Mapping, FFT, CP Insertion, and PA blocks, each with two parallel antenna paths (Ant 1 and Ant 2). The CRS generation block also feeds into the Mapping block. The output is connected to Femto Ant 1 and Femto Ant 2. Macro Transmitter (Interfering eNB): This block has a similar architecture to the Femto Transmitter, including Bit generation, Encoder, Modulation, CRS generation, STBC, Mapping, FFT, CP Insertion, and PA blocks, all with two parallel antenna paths (Ant 1 and Ant 2). The output is connected to Macro Ant 1 and Macro Ant 2. Receiver: This block includes a Tx CRS block, a Channel estimation block, an Equilization block, an Extraction block, a Decoder (comprising CRC Check and Viterbi), and a DeModulation (QPSK, QAM) block. The data path flows through IFFT, CP Removal, and AWGN blocks, each with two parallel antenna paths (Ant 1 and Ant 2). The Rx CRS block feeds into the Channel estimation block. The output is connected to RX Ant 1 and RX Ant 2. The three transmitters are connected to the Receiver via a Channel (Air interface). Figure 6.1: System model <u>3GPP TR 36.866 V12.0.1:</u> • Pages 54-55

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	9.1.5.2 Alternative 2 Generally, the system level modelling methodology for SLIC is carried out by two steps. The first step is to derive the post-processing SINR per subcarrier. After that, the simulator predicts the instantaneous BLER for each transmission block by a link quality model (such as MIESM, EESM etc.) based on the input SINRs. Here, we will only focuses on how to obtaining of post-processing SINRs. For simplicity, we assume the target UE eliminates the strongest interference, and only one layer is transmitted for both target UE and interfering UE. The received downlink signal for each subcarrier can be written as $y = H_s x_s + H_1 x_1 + \sum_{k=2}^{N-1} H_k x_k + n \quad (9.47)$ Where H_1 denotes the effective channel from the strongest interfering cell to the target UE and x_1 denotes the strongest interfering symbol. In the first place, the strongest interference signal is detected with its corresponding post-processed SINR, take MMSE receiver as an example, $\gamma_{MMSE-1st-inf} = w_{MMSE-1st-inf} \cdot \tilde{H}_1 / (1 - w_{MMSE-1st-inf} \cdot \tilde{H}_1) \quad (9.48)$ where $w_{MMSE-1st-inf} = \tilde{H}_1^H \left(\tilde{H}_1 \tilde{H}_1^H + \text{diag} \left(\tilde{H}_s \tilde{H}_s^H + \sum_{k=2}^{N-1} \tilde{H}_k \tilde{H}_k^H + \sigma_N^2 \cdot I \right) \right)^{-1} \quad (9.49)$ Once the strongest interference signal is detected, it could be removed from the received signal. However, the strongest interference signal cannot be completely removed in practical system. Let e_k denotes the residual error and $\bar{\sigma}$ be the variance of demodulated symbols residual error, $e = \tilde{H}_1 x_1 - \tilde{H}_1 \tilde{x}_1 = \tilde{H}_1 (x_1 - \tilde{x}_1), \quad \bar{\sigma} = \frac{1}{L} \sum_{l=1}^L \ x_{1,l} - \tilde{x}_{1,l}\ ^2, \quad (9.50)$ where L is the number of trials. <u>Qualcomm's '915 patent:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	<i>“Certain channels, most notably Common Reference Signal (CRS) tones and/or DRS tones, have a known sequence. Thus, the channel of the cell to be cancelled can be estimated based on the CRS tones or DRS tones. For example, the UE uses the CRS and/or DRS tones transmitted from an eNB to obtain estimates of the channels between the eNB and the UE. The UE then reconstructs the CRS tones or DRS tones based on the channel estimates and the known sequence, and can cells out the CRS tones or DRS tones. In this document, the CRS and/or the DRS reconstruction and cancellation procedure is referred to as “RS interference cancellation.” Control channels (PBCH, PCFICH, PHICH, PDCCH, R-PHICH (relay-PHICH), R-PDCCH (relay-PDCCH), and the like) and some data channels (PDSCH, R-PDSCH (relay PDSCH), and the like) have unknown payloads. For control channels and data channels that do not carry a Dedicated Reference Signal (DRS) tones (e.g., Demodulation Reference Signal (DMRS) tones), the UE relies on the channel estimates obtained from the CRS tones to decode, re-encode, reconstruct, and cancel out the channels. For control channels and data channels that have embedded DRS tones (e.g., Demodulation Reference Signal (DMRS) tones), the UE may rely on the channel estimates obtained from the DRS tones (e.g., Demodulation Reference Signal (DMRS) tones) to decode, re-encode, reconstruct, and cancel out the channels. Whether to use a CRS tones or a DRS tones (e.g., Demodulation Reference Signal (DMRS) tones) to obtain a channel estimate may be based at least in part on a type of the channel, transmission mode, and/or other parameters. For example, the Dedicated Reference Signal (DRS) tones may be trans mitted for each channel based at least in part on a request. For example, as described above, DRS tones may be imbedded in a same resource block with the control/data channels in order to obtain a channel estimate of a corresponding channel. In this document, the control and/or data channel re-</i>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	<i>encoding, reconstruction, and cancellation procedure is referred to as “control/data channel interference cancellation’.” [Col.11, Lines 52-67 – Col.12, Lines 1-21]</i> <i>“The approach of FIGS. 8-10 also works for a colliding CRS scenario and/or a colliding DRS Scenario, but the approach of FIGS. 6 and 7 may be selected for colliding CRS scenarios and/or colliding DRS scenarios for one or more reasons. It is generally the case that the approach of FIGS. 8-10 has a higher complexity than the approach of FIGS. 6 and 7. Furthermore, if an iterative interference cancellation approach is employed in a colliding CRS scenario and/or a colliding DRS scenario, it may be advantageous to use the approach of FIGS. 6 and 7 to reduce the number of iterations in control/data channel interference cancellation. Specifically, in an iterative approach of FIGS. 6 and 7, the control/data channel decoding on the serving and neighbor cells are performed with the final channel estimates that are obtained after all the CRS and/or DRS interference cancellation iterations are completed, whereas in an iterative approach according to FIGS. 8-10, the control/data channel decoding of the serving and neighbor cells are performed with intermediate channel estimates that are available on the given iteration. Because the intermediate channel estimates are less accurate than the final channel estimates, it is desirable to implement more iterations for the approach according to FIGS. 8-10 than for the approach according to FIGS. 6-7.” .” [Col.15, Lines 59-67 – Col.16, Lines 1-14]</i> <i>See also Claim 1, supra.</i>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	If this element is not literally satisfied by the disclosures cited herein, it is satisfied under the doctrine of equivalents, by the disclosures cited herein because the accused functionality would be insubstantially different from or function in the same way to provide the same result as the relevant claim element.
[9.b] means coupled to said channel transfer function determining signal processor for providing uninterrupted estimates of the channel transfer function parameters on a real-time basis,	The Accused 4G UE Instrumentalities include means coupled to said channel transfer function determining signal processor for providing uninterrupted estimates of the channel transfer function parameters on a real-time basis, This term is governed by 35 U.S.C. sec. 112 para. 6. The claimed function is providing uninterrupted estimates of the channel transfer function parameters on a real-time basis by first deriving the estimated channel transfer function for each of said interfering signals. The Accused 4G UE Instrumentalities make initial channel transfer function estimates during setting up a data connection. In the case of colliding (interfering) reference symbols received at the UE from streams of different cells, such as CRS or DMRS symbols, means coupled to the UE channel transfer function determining signal processor are used to provide uninterrupted estimates of the channel transfer function parameters on a real-time basis. This can enhance channel transfer function estimates of each user. For example, the means utilizes the initial estimates of the channel transfer function for each user to carry out an iteration to reconstruct the reference symbols of the users that cause interference to the reference symbols of a user by using the existing channel estimates to cancel the estimated interfering reference symbols from the received signal. This iteration updates the channel transfer function estimates of each user. Thus, the Accused 4G UE Instruments provide uninterrupted estimates of the channel transfer function parameters on a real-time basis.

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	The corresponding structure is a parameter tracking unit and equivalents thereof. See, e.g., fig. 1, Col.5, Lines 20-40, Col. 6, Lines 9-23, fig. 3, fig. 4 (item 90, 90', 90'), Col 7, Lines 45-Col 8, Line 40. As described above, The Accused 4G UE Instrumentalities need estimates of the channel (“channel transfer function”) between the eNB and the UE to estimate symbols of the multiple users/data streams for interference cancellation/suppression or for data demodulation. Channel estimation is a signal processing task and is to be carried out by a signal processor in the UE. At acquisition time, when a UE selects and acquires the signal transmitted by a base station, the UE needs to acquire and estimate, e.g., system timing, frequency, Doppler and effects of multipaths in the channel. For instance, in an OFDM system, the effects of multipath, phases and gains superimposed on the different resource elements (frequency tones), are estimated using reference symbols transmitted by the base stations. Parameters corresponding to timing, frequency offset, Doppler and effects of multipaths are estimated in acquisition state and tracked when on the traffic channel in a connected state. Acquisition and estimation of these parameters is a signal processing function carried out by a signal processing module ("parameter estimation unit"). When the UE transitions from the acquisition state to the connected state a UE channel parameter tracking module ("tracking unit") uses the channel parameters from the acquisition state and tracks these parameters to maintain the call when on the traffic channel. <u>TSG-RAN WG1, Contribution # R4-121447:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	2.1. FeICIC Baseline Receiver Assumptions We start to define the baseline receivers in more detail by describing them verbally. • A CRS puncturing receiver is any kind of receiver that punctures REs of the wanted signal of the serving cell that are heavily interfered by CRS REs received from one or more dominant interfering cells. Knowledge of the CRS REs of the interfering cell(s) is assumed. Obviously, the punctured REs cannot be CRS REs of the serving cell. Hence, the CRS puncturing receiver not applicable in scenarios with colliding CRS. Transmitter side solutions, e.g. PDSCH muting corresponding to the CRS patterns of neighbor cells, are not considered as part of a CRS puncturing receiver. A CRS puncturing receiver is principally applicable to e.g. PDSCH and PDCCH with non-colliding CRS. • A CRS canceling receiver is any kind of receiver that cancels CRS REs received from one or more dominant interfering cells from the wanted signal of the serving cell. Knowledge of the CRS REs of the interfering cell(s) is assumed. Canceling CRS REs from the wanted signal requires channel estimation of the channel from the UE to interfering cell. The wanted signal can be any kind of channel sent by the serving cell including PDSCH, PDCCH, serving cell CRS, etc. Hence, CRS canceling receivers can be applied both in scenarios with colliding and non-colliding CRS. A CRS cancelling receiver is principally applicable to e.g. PDSCH and PDCCH. Figure 1 outlines the basic processing flow in the base line receiver consisting of channel estimation, CRS puncturing/canceling, MMSE based demodulation, e.g. for PDSCH, and decoding. Derivations from this processing flow are implementation specific and do not need to be defined for the base line receiver. <pre> graph LR A[Channel Estimation] --> B[CRS puncturing or canceling] B --> C[PDSCH Demodulation (MMSE)] C --> D[Decoding] </pre> Figure 1: Basic Receiver Diagram for PDSCH

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	According to the description for CRS canceling receivers above it needs to be distinguished between colliding and non-colliding CRS. Considering one RE only, the CRS IC system model for both cases can be written in a simplified way as: $\text{CRS IC for colliding CRS : } y_p = h_1 \cdot x_p^{(1)} + h_2 \cdot x_p^{(2)} + n \Rightarrow y_p - \hat{h}_2 \cdot x_p^{(2)}$ $\text{CRS IC for non-colliding CRS : } y_d = h_1 \cdot x_d^{(1)} + h_2 \cdot x_p^{(2)} + n \Rightarrow y_d - \hat{h}_2 \cdot x_p^{(2)}$ Here h_1 and h_2 denote the serving and interfering channel vector (matrix) and $x_p^{(i)}$ and $x_d^{(i)}$, respectively, represent pilot and data symbols, where $i = 1$ indicates the serving cell. y_p and y_d are the received REs. In both cases the interfering channel is estimated and $\hat{h}_2 \cdot x_p^{(2)}$ is subtracted from y_p and y_d. It is seen that in case of colliding CRS canceling interfering CRS mainly aims to improve channel estimation performance of the serving cell whereas in case of non-colliding CRS canceling interfering CRS aims to improve directly e.g. PDSCH and PDCCH performance. In this case channel estimation performance in the serving cell is not improved as long as no iterative receiver is applied. The RAN1 LS [1] states that both colliding and non-colliding CRS scenarios should be considered. As already mentioned, a puncturing receiver is not applicable to non-MBSFN/MBSFN ABS with colliding CRS, whereas a CRS canceling receiver can be applied both to colliding and non-colliding CRS scenarios. Hence, a CRS canceling receiver should be assumed as baseline for colliding CRS both in MBSFN and non-MBSFN ABS. <u>Qualcomm's '915 patent:</u> <i>“FIG. 6A is a block diagram conceptually illustrating a colliding CRS scenario before interference cancellation is performed, according to one aspect of the present disclosure. In FIG. 6A, the horizontal axes represent frequency. Reference signal (e.g., CRS) tones and control/data tones are shown for a Sub carrier of a neighbor cell and a serving cell. As shown in FIG. 6A, serving cell CRS tones see interference from the CRS tones of the neighbor cell. To improve interference cancellation results, according to one aspect the UE decouples CRS interference cancellation and control/data channel interference cancellation in a colliding CRS tone scenario. That is, the UE first performs CRS interference cancellation to estimate</i>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	<i>the serving cell channels and then proceeds with neighbor cell and serving cell control/data channel interference cancellation and decoding.” [Col.12, Lines 63 – Col.13, Lines 10]</i> <i>“In one example, the UE performs the decoupled interference cancellation/channel estimation process as described above based on CRS tones and/or DRS tones according to the following order (e.g., when the neighboring cell is stronger):</i> <i>1. Neighbor cell channel estimation:</i> <i>2. Neighbor cell CRS interference cancellation and/or neighbor cell DRS interference cancellation;</i> <i>3. Serving cell channel estimation;</i> <i>4. For iterative interference cancellation (e.g., when the cells are of similar strength), perform serving cell CRS interference cancellation and/or perform serving cell DRS interference cancellation and repeat 1-4 a number of times in a well-known manner.</i> <i>5. Neighbor cell control/data channel decoding:</i> <i>6. Neighbor cell control/data channel interference cancellation;</i> <i>7. Serving cell control/data channel decoding:</i>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	<i>See also</i> Claim 1, <i>supra</i>. If this element is not literally satisfied by the disclosures cited herein, it is satisfied under the doctrine of equivalents, by the disclosures cited herein because the accused functionality would be insubstantially different from or function in the same way to provide the same result as the relevant claim element.
[9.c] said multi-user detection system including a tracking unit for acquired signals, and in the presence of a new signal in an acquisition channel of said parameter estimation unit	The Accused 4G UE Instrumentalities include said multi-user detection system including a tracking unit for acquired signals, and in the presence of a new signal in an acquisition channel of said parameter estimation unit estimating the channel transfer function prior to signal switching from the acquisition channel to a traffic channel, with said parameter estimation unit parameters being passed to said tracking unit thereafter, all received signals having training portions. For example, LTE uses Synchronization Signal Block (SSB) (“acquisition channel”) to detect the signal transmitted by an eNB, acquire timing, and estimate frequency offset, Doppler, and initial channel parameters to decode the PBCH channel. After synchronization the UE enters idle or connected mode. The synchronization signal identifies the physical-layer cell ID that is further used by the CRS to estimate the channel transfer function. The channel transfer function parameters from the acquisition state are carried

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
estimating the channel transfer. function prior to signal switching from the acquisition channel to a traffic channel, with said parameter estimation unit parameters being passed to said tracking unit thereafter, all received signals having training portions,	over to the next call state of idle or connected mode to track timing, frequency offset, Doppler frequency, and estimated channel parameters. <u>LTE Book:</u> Synchronization and Cell Search 7.1 Introduction A User Equipment (UE) wishing to access an LTE cell must first undertake a <i>cell search procedure</i>. This chapter focuses on the aspects of the physical layer that are designed to facilitate cell search. The way this relates to the overall mobility functionality and protocol aspects for cell reselection and handover is explained in Chapters 3 and 22. The performance requirements related to cell search and synchronization are explained in Section 22.2. <u>At the physical layer, the cell search procedure consists of a series of synchronization stages by which the UE determines time and frequency parameters that are necessary to demodulate the downlink and to transmit uplink signals with the correct timing. The UE also acquires some critical system parameters.</u> Three major synchronization requirements can be identified in the LTE system: 1. Symbol and frame timing acquisition, by which the correct symbol start position is determined, for example to set the Discrete Fourier Transform (DFT) window position; 2. Carrier frequency synchronization, which is required to reduce or eliminate the effect of frequency errors¹ arising from a mismatch of the local oscillators between the transmitter and the receiver, as well as the Doppler shift caused by any UE motion; 3. Sampling clock synchronization. (Also discussing the three major synchronization requirements).

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	7.2 Synchronization Sequences and Cell Search in LTE The cell search procedure in LTE begins with a synchronization procedure which makes use of two specially designed physical signals that are broadcast in each cell: the Primary Synchronization Signal (PSS) and the Secondary Synchronization Signal (SSS). The detection of

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	these two signals not only enables time and frequency synchronization, but also provides the UE with the physical layer identity of the cell and the cyclic prefix length, and informs the UE whether the cell uses Frequency Division Duplex (FDD) or Time Division Duplex (TDD). In the case of initial synchronization (when the UE is not already camping on or connected to an LTE cell) after detecting the synchronization signals, the UE decodes the Physical Broadcast CHannel (PBCH), from which critical system information is obtained (see Section 9.2.1). In the case of neighbour cell identification, the UE does not need to decode the PBCH; it simply makes quality-level measurements based on the reference signals (see Chapter 8) transmitted from the newly detected cell and uses them for cell reselection (in RRC_IDLE state) or handover (in RRC_CONNECTED state); in the latter case, the UE reports these measurements to its serving cell. The cell search and synchronization procedure is summarized in Figure 7.1, showing the information ascertained by the UE at each stage. The PSS and SSS structure is specifically designed to facilitate this acquisition of information. <pre> graph TD PSS[PSS Detection] --> SSS[SSS Detection] SSS --> Neighbour[Neighbour cell identification] SSS --> Initial[Initial synchronization] Neighbour --> RS[RS Detection] Neighbour --> RSRQ[RSRP/RSRQ measurement and reporting] Initial --> PBCH[PBCH Decoding] PBCH --> PBCH_Info[PBCH timing detection
System information access] </pre> The flowchart illustrates the cell search procedure. It begins with PSS Detection, which leads to SSS Detection. From SSS Detection, the process branches into two paths: Neighbour cell identification and Initial synchronization. The Neighbour cell identification path involves RS Detection and RSRP/RSRQ measurement and reporting. The Initial synchronization path involves PBCH Decoding, which then leads to PBCH timing detection and System information access. The PSS Detection step also provides Slot Timing detection and Physical layer ID. The SSS Detection step provides Radio Frame Timing detection, Cell ID, Cyclic Prefix length detection, and TDD/FDD detection. Figure 7.1: Information acquired at each step of the cell search procedure.

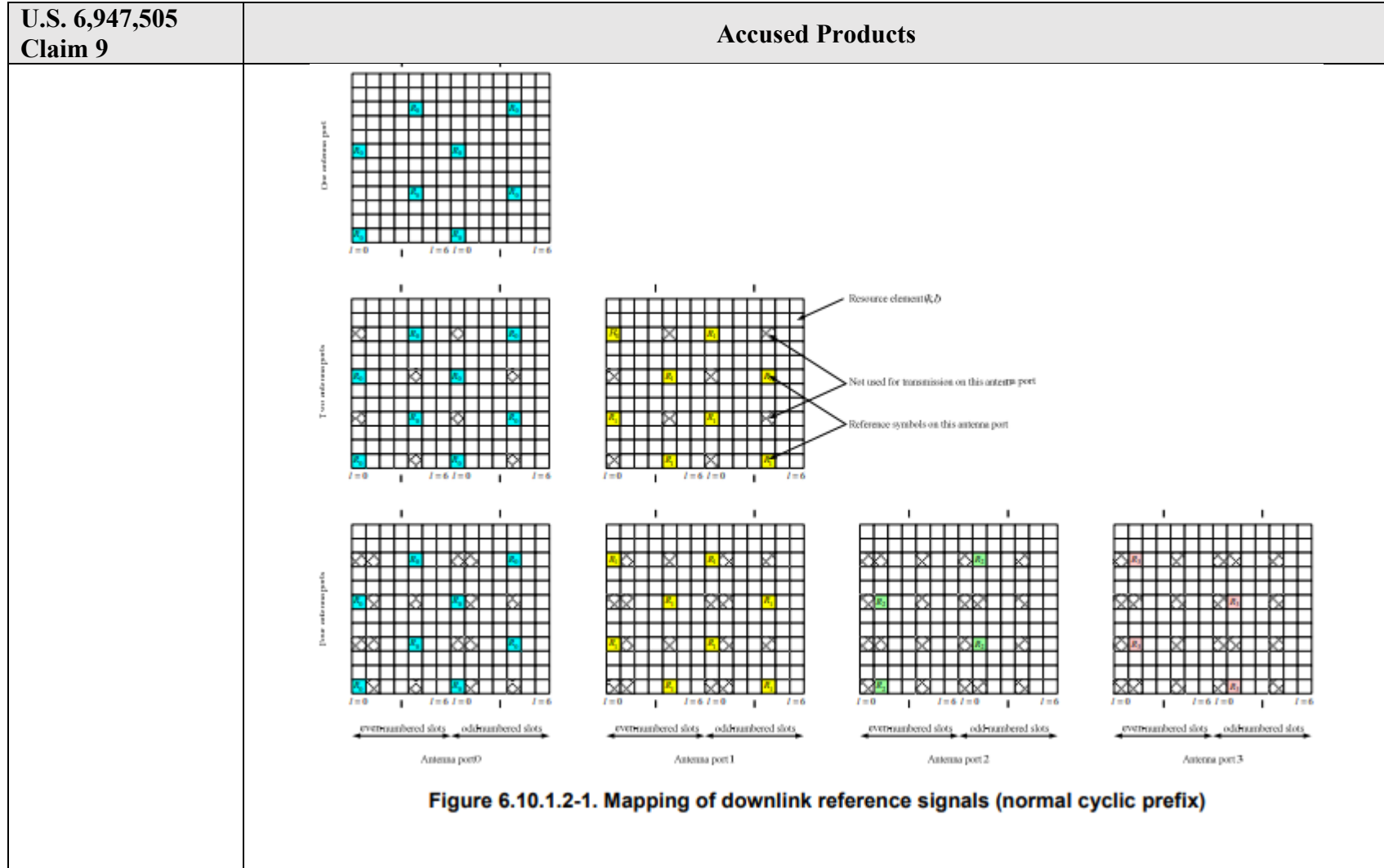
**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	<u>LTE Book:</u> Control Plane Protocols 3.1 Introduction As introduced in Section 2.2.2, the Control Plane of the Access Stratum (AS) handles radio-specific functionalities. The AS interacts with the Non-Access Stratum (NAS), also referred to as the ‘upper layers’. Among other functions, the NAS control protocols handle Public Land Mobile Network¹ (PLMN) selection, tracking area update, paging, authentication and Evolved Packet System (EPS) bearer establishment, modification and release. The applicable AS-related procedures largely depend on the Radio Resource Control (RRC) state of the User Equipment (UE), which can be either RRC_IDLE or RRC_CONNECTED. A UE in RRC_IDLE performs cell selection and reselection – in other words, it decides on which cell to camp. The cell (re)selection process takes into account the priority of each applicable frequency of each applicable Radio Access Technology (RAT), the radio link quality and the cell status (i.e. whether a cell is barred or reserved). An RRC_IDLE UE monitors a paging channel to detect incoming calls, and also acquires system information. The System Information (SI) mainly consists of parameters by which the network (E-UTRAN) can control the cell (re)selection process. <u>In RRC_CONNECTED, the E-UTRAN allocates radio resources to the UE to facilitate the transfer of (unicast) data via shared data channels.² To support this operation, the UE monitors an associated control channel³ used to indicate the dynamic allocation of the shared transmission resources in time and frequency.</u> The UE provides the network with reports of its <u>TS 36.211 version 17.1.0:</u>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	6.10 Reference signals Six types of downlink reference signals are defined: - <u>Cell-specific Reference Signal (CRS)</u> - MBSFN reference signal - <u>UE-specific Reference Signal (DM-RS) associated with PDSCH</u> - DeModulation Reference Signal (DM-RS) associated with EPDCCH or MPDCCH - Positioning Reference Signal (PRS) - CSI Reference Signal (CSI-RS) There is one reference signal transmitted per downlink antenna port. 6.10.1 Cell-specific Reference Signal (CRS) The UE may assume cell-specific reference signals are, unless otherwise stated in [4, clause 12], transmitted in - all downlink subframes for frame structure type 1, - all downlink subframes and DwPTS for frame structure type 2, - non-empty subframes for frame structure type 3 in a cell supporting PDSCH transmission. If special subframe configuration 10 is configured by the higher layer signalling <i>ssp10-CRS-LessDwPTS</i>, the UE cannot assume that cell specific reference signals are transmitted in the 5th OFDM symbol of the special subframe. Cell-specific reference signals are transmitted on one or several of antenna ports 0 to 3. Cell-specific reference signals are transmitted in subframes where $\Delta f = 15$ kHz only. <u>Figures 6.10.1.2-1 and 6.10.1.2-2 illustrate the resource elements used for reference signal transmission according to the above definition. The notation R_p is used to denote a resource element used for reference signal transmission on antenna port p.</u>

INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3



**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	Figure 6.10.1.2-2. Mapping of downlink reference signals (extended cyclic prefix) <i>See also Claim 1, supra.</i>

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	If this element is not literally satisfied by the disclosures cited herein, it is satisfied under the doctrine of equivalents, by the disclosures cited herein because the accused functionality would be insubstantially different from or function in the same way to provide the same result as the relevant claim element.
[9.d] a second interfering signal being and assigned to said traffic channel, said parameter estimation unit recreating the training signal portion of every received signal prior to the last received signal and subtracting the recreated training signals from the	The Accused 4G UE Instrumentalities include said multi-user detection system including a second interfering signal being and assigned to said traffic channel, said parameter estimation unit recreating the training signal portion of every received signal prior to the last received signal and subtracting the recreated training signals from the training portion of the last received signal to provide an estimate solely due to the last received signal during the training Signal portion, thus to allow an estimate of the last signal from which to calculate parameters of the last signal. For example, in a cellular network there are multiple cell sites, each transmitting common and traffic channels to the UEs. UE receiving data from the serving cell will receive interference from a traffic channel transmitted by a neighboring cell site. The parameter estimation unit uses the reference symbols (e.g., CRS symbols) transmitted by a cell site to estimate its channel transfer function, reconstructs the CRS symbols using the channel estimates and subtracts the reconstructed reference symbols from the total received signal to enable a more accurate estimate of channel transfer function of a second signal transmitted by another cell site. <u>TSG-RAN WG1, Contribution # R4-121447:</u> 2.1.FelCIC Baseline Receiver Assumptions

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
training portion of the last received signal to provide an estimate solely due to the last received signal during the training signal portion, thus to allow an estimate of the last signal from which to calculate parameters of the last signal.	We start to define the baseline receivers in more detail by describing them verbally. • A CRS puncturing receiver is any kind of receiver that punctures REs of the wanted signal of the serving cell that are heavily interfered by CRS REs received from one or more dominant interfering cells. Knowledge of the CRS REs of the interfering cell(s) is assumed. Obviously, the punctured REs cannot be CRS REs of the serving cell. Hence, the CRS puncturing receiver not applicable in scenarios with colliding CRS. Transmitter side solutions, e.g. PDSCH muting corresponding to the CRS patterns of neighbor cells, are not considered as part of a CRS puncturing receiver. A CRS puncturing receiver is principally applicable to e.g. PDSCH and PDCCH with non-colliding CRS. • A CRS canceling receiver is any kind of receiver that cancels CRS REs <u>received from one or more dominant interfering cells from the wanted signal of the serving cell. Knowledge of the CRS REs of the interfering cell(s) is assumed. Canceling CRS REs from the wanted signal requires channel estimation of the channel from the UE to interfering cell. The wanted signal can be any kind of channel sent by the serving cell including PDSCH, PDCCH, serving cell CRS, etc. Hence, CRS canceling receivers can be applied both in scenarios with colliding and non-colliding CRS. A CRS cancelling receiver is principally applicable to e.g. PDSCH and PDCCH.</u> Figure 1 outlines the basic processing flow in the base line receiver consisting of channel estimation, CRS puncturing/canceling, MMSE based demodulation, e.g. for PDSCH, and decoding. Derivations from this processing flow are implementation specific and do not need to be defined for the base line receiver. <pre> graph LR A[Channel Estimation] --> B[CRS puncturing or canceling] B --> C[PDSCH Demodulation (MMSE)] C --> D[Decoding] </pre> Figure 1: Basic Receiver Diagram for PDSCH

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

U.S. 6,947,505 Claim 9	Accused Products
	According to the description for CRS canceling receivers above it needs to be distinguished between colliding and non-colliding CRS. Considering one RE only, the CRS IC system model for both cases can be written in a simplified way as: $\text{CRS IC for colliding CRS : } y_p = h_1 \cdot x_p^{(1)} + h_2 \cdot x_p^{(2)} + n \Rightarrow y_p - \hat{h}_2 \cdot x_p^{(2)}$ $\text{CRS IC for non-colliding CRS : } y_d = h_1 \cdot x_d^{(1)} + h_2 \cdot x_p^{(2)} + n \Rightarrow y_d - \hat{h}_2 \cdot x_p^{(2)}$ Here h_1 and h_2 denote the serving and interfering channel vector (matrix) and $x_p^{(i)}$ and $x_d^{(i)}$, respectively, represent pilot and data symbols, where $i = 1$ indicates the serving cell. y_p and y_d are the received REs. <u>In both cases the interfering channel is estimated and $\hat{h}_2 \cdot x_p^{(2)}$ is subtracted from y_p and y_d. It is seen that in case of colliding CRS canceling interfering CRS mainly aims to improve channel estimation performance of the serving cell whereas in case of non-colliding CRS canceling interfering CRS aims to improve directly e.g. PDSCH and PDCCH performance. In this case channel estimation performance in the serving cell is not improved as long as no iterative receiver is applied.</u> The RAN1 LS [1] states that both colliding and non-colliding CRS scenarios should be considered. As already mentioned, a puncturing receiver is not applicable to non-MBSFN/MBSFN ABS with colliding CRS, whereas a CRS canceling receiver can be applied both to colliding and non-colliding CRS scenarios. Hence, a CRS canceling receiver should be assumed as baseline for colliding CRS both in MBSFN and non-MBSFN ABS. <i>See also Claim 1, supra.</i> If this element is not literally satisfied by the disclosures cited herein, it is satisfied under the doctrine of equivalents, by the disclosures cited herein because the accused functionality would be insubstantially different from or function in the same way to provide the same result as the relevant claim element.

**INFRINGEMENT CONTENTIONS – CHART FOR U.S. PAT. NO. 6,947,505
EXHIBIT 3**

References:

1. <https://www.scribd.com/document/181665971/LTE-Advanced> (“Qualcomm LTE Advanced Presentation”) (Release August, 2013)
2. <https://www.slideshare.net/qualcommwirelessevolution/lte-advanced-evolvingandexpandingintonewfrontiersv1020140226> (“Qualcomm LTE Advanced - Evolving and expanding into new frontiers Presentation”) (Release March 2014)
3. <https://www.scribd.com/document/252110973/lte-good-ref> (“Qualcomm Interference Management Presentation”)
4. <https://www.scribd.com/document/132432839/Qualcomm-Research-LTE-Heterogeneous-Networks> (“Qualcomm Heterogeneous Network”)
5. https://opendevdevelopment.verizonwireless.com/content/dam/opendevdevelopment/pdf/OpenAccessReq/Reqs_LTE_3GPP_Band13_NetworkAccess_Feb2019.pdf (“Verizon Wireless Requirements Plan”)
6. (TS 36.331 version 17.0.0)*
7. (TS 36.211 version 17.1.0)*
8. (3GPP TR 36.866 V12.0.1)
9. (“TSG-RAN WG1, Contribution # R4-121447”)
10. (“TSG-RAN WG4, Contribution # R4-126146”)
11. U.S. Patent No. 9,425,915 to Yoo et al (“Qualcomm’s ’915 patent”)
12. <https://dl.icdst.org/pdfs/files/060ab2bbf9dbe18f5618e66fc41506f8.pdf> LTE The UMTS Long Term Evolution, Second Edition, Wiley (“LTE Book”)
13. https://www.sharetechnote.com/html/Handbook_LTE_PhyParameter_DL_FDD.html (LTE Resource Blocks vs Bandwidth)
14. https://www.sharetechnote.com/html/FrameStructure_DL.html#RS (LTE CRS Reference Symbols)
15. <https://www.diva-portal.org/smash/get/diva2:651719/FULLTEXT01.pdf> (Understanding ICI in LTE HetNet, Thesis)
16. <https://teletopix.org/4g-lte/what-is-crs-in-lte/> (CRS in LTE)

**The evidence provided from these references was released in release 11 of the standard document.*